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EXECUTION MANUAL FOR TIME-SHARED STRUCTURAL MECHANICS PROGRAMS --ETC(U)
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Execution Manual for Time-Shared Structural Mechanics Programs on the University of Maryland Univac - 1108

Harry G. Schaeffer

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EXECUTION MANUAL FOR TIME-SHARED STRUCTURAL MECHANICS PROGRAMS ON THE UNIVERSITY OF MARYLAND UNIVAC-1108.

by

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ABSTRACT

A set of user oriented computer programs for structural analysis was developed in conjunction with the International Symposium on Structural Mechanics Software which was held at the University of Maryland in June, 1974. This report describes the use and operation of those programs which were resident on the University of Maryland computer system. These programs include:

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Table of Contents

1. Introduction

The purpose of this manual is to describe the execution of pre- and post-processors and their associated analysis programs on the University of Maryland Univac 1108. The manual contains sections which describe system attributes affecting the execution of the programs; and sections which describe those programs available in the library.

The Univac 1108 operating under the EXEC 8 operating system supports two modes of access simultaneously. These modes are "Demand" and "Batch". The demand mode allows the user to access the computer by means of a remote terminal; and with minor exceptions makes all of the system features normally available to "batch" users available to "demand" users in a real-time environment.

In the demand mode the user may utilize system programs for file management, for file editing and for submission of programs for execution. In the Univac 1108 EXEC 8 environment there is no difference between a demand program and a batch program; a program may be executed in either mode. However; the computer operations staff may restrict the demand user to a smaller core than that available in batch. (The author has exercised NASTRAN in the demand mode; and, the system responds by executing the program immediately.)

The "demand" environment is a new world for those of us who have graduated successively from the earliest programmable computers to those of 3rd generation machines with operating systems which allow man-machine interaction. The purpose of developing these pre-processors and the associated analysis programs in this environment is to provide a model, however unsophisticated, that will serve as an indication of the direction that computer usage is taking.

2. General Procedures

2.1. Connecting up to the machine

The procedure for connecting to the computer varies with the type of terminal and telephone equipment being used. One first starts by turning the terminal (and sometimes telephone equipment) on, and dialing the computer. A busy signal means that all incoming lines to the computer are in use. A no-answer may mean the computer is shut down, but during normal hours usually means that the system has just "crashed" and is being re-started. A high-pitched "tone" indicates the computer is ready. If a teletype with an integral dial is being used, the connection is now complete; if a Bell System data set is used, one should press the "DATA" button and cradle the handset; users of acoustic couplers should place their telephone handset in the coupler.

After establishing the connection (and before typing anything else), hit the "BREAK" key on your terminal. If the system responds with *OUTPUT INTERRUPTED*, you have dialed into a telephone line whose previous user did not hang up properly. Type the single string '@@X TIØ' followed by a carriage return and then an @FIN command to get rid of the previous user's run. After printing the accounting information for the previous user, the system will request your account number. You should then proceed as below under "identifying yourself".

If the system does not respond to the "BREAK", proceed to identify your terminal as noted below.

2.1.1. Identifying your terminal

Once the connection is established, you must identify the terminal being used by typing in a valid site I.D. number which will be made available to qualified users. A valid site I.D. should result in a response from the computer. Occasionally, the system may not respond to a valid site I.D. If retyping it several times does not help, consult the "trouble shooting" tables in Appendix A for corrective action.

Once the terminal has been identified, it is available for use. Any number of independent @RUN's may be signed on and terminated (@FIN'ed) while the terminal is "active". The system will allow a terminal to be active for a brief period when no job is actively using it (i.e. at initial sign-on or after a previous job has @FIN'ed); if no new @RUN's start within the allotted time, the system will automatically disconnect the terminal.

2.1.2. Identifying yourself

Once the terminal is active, the system will ask you to identify yourself by typing, "ACCOUNT NUMBER?". In response to this, you may type:

(1) only your account number
(2) any or all fields of an EXEC8 "RUN" card starting with the account number and continuing with project, time estimates, etc.
(3) an entire EXEC8 @RUN card image as shown below:

@RUN <RUNID>, <ACCOUNT NUMBER>, <PROJECT ID>, <TIME>, <PAGES>

where

RUNID is the six character identification given to this session. If omitted the system will generate an I.D. The user is cautioned to record this I.D. for use in identifying high-speed printer output.

ACCOUNT NUMBER is made available to authorized users.

PROJECT ID is a twelve character I.D. which becomes the file qualifier if present.

TIME is the maximum execution time in minutes.

PAGES is the maximum number of pages of output.

In most cases, alternative (3) is recommended in order to provide complete accounting information. After entering the above information, depress the carriage return (C-R) to inform the system that you are finished. It will respond by asking for your password, which should then be typed in. Valid account numbers and associated passwords will be supplied to qualified users.

If any errors occur in the sign-on procedure, the system will ask for the account number again. Otherwise, it will print your RUNID and today's time and date. The RUNID is internally generated if options (1) or (2) are taken in entering the account number. If the entire @RUN card is supplied then the RUNID is taken from the @RUN card. The user is cautioned to record the RUNID since it will be required to identify output that is directed to one of the high-speed printers.

After sign-on is complete, the system will inform you of the status of your workspace (which is a special file called the TPF$.) This is a protected area of drum which the system establishes for you as a work area. Normally the workspace is discarded when you terminate a terminal session and a new one is established at the next terminal session. If the system crashes during a terminal session, however, the workspace will be retained and recovered the first time you sign on after the crash.

Since system crashes rarely involve "down" times of more than a few minutes, workspaces which are saved because of a system crash are short-lived. They will usually be immediately available if one signs back on to the machine on the day of the crash. If not recovered on that day, they will be rolled out onto tape, and a short wait will be required to recover them. Workspaces not recovered within two days after being rolled out to tape are purged from the system.

2.2. Typing Terminal Input

2.2.1. Editing Input Lines

Input to the system from a demand terminal is processed a line at a time as it is typed; each line must be followed by a C-R before it will be accepted. At any time before the C-R key is typed, the line may be edited. Typing a question mark will cause the entire line to be deleted; typing an underline (back arrow on some teletype terminals) will cause deletion of the last non-deleted character on a line (thus the last four characters are deleted by typing four underlines). Although the system will accept either upper or lower case input, lower case letters will be translated into upper case.

2.2.2. ASCII Control Codes

When in normal (not full ASCII) input mode, many of the ASCII communications control codes have special meaning. On teletype terminals, these codes are usually generated by holding down the CTRL key and striking an alphabetic key, although some (like ESC) have a key of their own. Control codes not noted in the table below are translated by the system into question marks. The codes which are used are:

CODE	KEY	USE
XON	CTRL-Q	start form I paper tape input (see EXEC8 PRM)
XOFF	CTRL-S	terminate form I mode (must be sent twice)
TAPE	CTRL-R	start form II paper tape input (see PRM)
T-A-P-E	CTRL-T	terminate form II
SHIFT-OUT	CTRL-N	start full ASCII input (see UOM documentation)
SHIFT-IN	CTRL-O	terminate full ASCII input

WRU or ENQ	CTRL-E	causes system to echo its sign-on line, useful in determining whether system is "up"
EOT	CTRL-D	disconnects terminal from computer
RUBOUT	RUBOUT	ignored
BREAK	BREAK	interrupts currently executing program, see below
ESC	ESC	can be used before typing question mark to allow input of question mark rather than deletion of line

2.2.3. Interrupting the Computer

The BREAK key on teletype terminals is used to interrupt the computer. When BREAK is hit, the computer will respond with *OUTPUT INTERRUPTED*, temporarily suspend what it is doing, and wait for input describing further action to be taken. The currently defined actions are:

@@X TIØ	Abort whatever is going on and return control immediately to the system executive. If any printout was produced prior to the break, it will be printed before the system waits for input.
?	Ignore the Break and continue. Especially useful when using CRT display terminals to "freeze" the contents of the screen for examination before proceeding.
C-R	Interrupt the current action of the executing program and wait for input. This action is specific to the @ED, @APL, and @BASIC processors. In other circumstances, BREAK-C-R is equivalent to BREAK-X.

2.3. System Functions

In order to utilize the terminal device to access the computer and execute the program the user must have the capability to:

(1) Create files
(2) Move files
(3) Purge files
(4) Edit files
(5) Call for program execution

The treatment given to these commands will be sufficient to allow the use of the system, but will be brief and incomplete. The user should consult references (3) and (4) for more detail.

2.3.1. Files and elements

Users familiar with other timesharing systems should note that the EXEC8 concept of a "file" is more generalized than that of many other systems. A file is a collection of entities called elements. Since files contain elements the file-naming procedure must be capable of identifying a specific element of a file. The file name convention is as follows:

QUALIFIER*FILENAME.ELEMENTNAME

The various parts of the name may be omitted by the user with default values as follows.

QUALIFIER	Taken to be: (1) The project I.D. if given on the @RUN card (2) The first six digits of the account number
FILENAME	Taken to be a special file called the TPF$ if omitted. The TPF$ is the user's workspace.

Suppose, for example, that a user had logged on using the project I.D. "SYMPOSIUM", and wished to identify the element ELMT in the file SYMPOSIUM* TPF$.   ; then the specification of ELMT in a suitable system command would be sufficient, since the system would supply the correct default names for the qualifier and file name.

The user should note that the file is the basic cataloged entity on the EXEC8 system. A file is almost always indicated by a terminating period (.). The period may be omitted only when the system would understand that a file is designated if omitted.

2.3.2. Creating and Cataloging Files

The following sequence of commands will catalog (save) a file:

```
@CAT,U FILE,F
@FREE FILE.
@ASG,A FILE.
```

At this point FILE exists but is empty. Data or elements may now be entered into the file by using the text editor a described in section 2.3.6.

2.3.3. Moving Files

The user may operate directly on a file in permanent storage, or alternatively on a copy of the file in the TPF$. The @COPY command is used to copy the file's contents from one storage location to another. The form of command is:

```
@COPY <SPEC1>, <SPEC2>
```

where

SPEC1 is the file name of the file contents to be moved, if blank the TPF$ is assumed.

SPEC2 is the file name for the destination of the file contents, if omitted, the TPF$. is assumed.

2.3.4. Assigning Files

Files may be created for the duration of the run by the command

@ASG,T FILENAME,F

A file that already exists may be assigned to the present run by the command

@ASG,A FILENAME.

2.3.5. Purging Files

The user may purge a permanent cataloged file by the command

@DELETE FILENAME.

If the file is temporarily assigned to the run, it may be purged by the command

@FREE FILENAME.

The @FREE command frees a file from the current run. If it is desired to erase the current contents of a file the following command may be used

@ERS FILENAME.

2.3.6. Text Editor

The University of Maryland text editor is described by reference 2. We will give a brief description of the features which are required to create and edit data files.

The editor is called by the command @ED <Spec>, where <Spec> refers to an element or a file. The editor operates in two modes; EDIT and INPUT. If the file is empty, the editor assumes the INPUT mode; otherwise, the EDIT mode is assumed. Mode change is affected by a C-R.

2.3.6.1. Input mode

In this mode any character date entered on the keyboard is entered in the file. Each physical line of input is terminated by a C-R. The system editing

features described in section 2.2.1. are available in this mode. The input mode is terminated two successive C-R's; if an @-sign is entered in either mode the editing session is terminated and control is returned to the system executive.

2.3.6.2 Edit Mode

In this mode the editor prompts the user with an asterisk (*) to enter an edit command. The U of M text editor has a great deal of sophistication; however a few commands will suffice for our purposes. The form of the command is a command mnemonic followed by a blank with control information.

Command	Description
G LN	Go to and print line number LN
L String	Locate and print the first line in which "string" occurs
N L	Move down L lines and print
U L	Move up L lines and print
C #String#String1#	At the current line, change String to String1. The delimiters (#) may be <u>any</u> character not included in the string.
P L	Print L lines of text starting with the current line.
O L	Print L lines of text starting with the next line.
D L	Delete L lines of text, starting with the current line.
T	Position the pointer to the top of the file
E	End the editing session

2.3.7. Redirecting Output

The program output in either mode may be redirected (from the terminal or the line printer for demand and batch, respectively) by the use of the @BRKPT command. The form of the command is,

@BRKPT PRINT$/FILENAME

where FILENAME is NOT terminated by a period.

The file must be cataloged.

If we desired to redirect the output to a file called OUT, for example, the following sequence of commands could be used:

@CAT,U OUT,F	(catalog the file)
@FREE OUT.	(free the file)
@ASG,A OUT.	(assign with A-option)
@BRKPT BRINT$/OUT	(direct the print file to OUT)

On the teletype all output is now redirected to OUT. *To redirect the* output back to the teletype type:

@BRKPT PRINT$

2.3.8. Program Execution

The EXEC 8 features which are available to the demand user are discussed in references (3) and (4). *We will present only those commands which are required* for the execution of programs in either batch or demand mode. The basic difference in the two modes is that demand programs are executed immediately in real time while batch requests are submitted to the batch-queue. The advantage of the latter is that the terminal is free to perform other tasks during batch execution of the program.

2.3.8.1. Demand Execution

The symposium input data processors (IDP) and their associated analysis programs are saved on the files

SYMPOSIUM*PREPROCESSOR.

and

SYMPOSIUM*PROGRAM.

The user may interrogate either file to determine the available executable modules by using the system command.

@PRT,T <FILENAME>

After determining the contents of the files, any of the absolute modules may be executed directly in the demand mode by the system command

@XQT <SPEC>

where <SPEC> is the complete element name for the executable module. For example the element SAP exists in the preprocessor file, and may be executed by the command.

@XQT SYMPOSIUM*PREPROCESSOR.SAP

2.3.8.2. Batch Execution

There are at least two ways to submit a job to the batch queue for execution; these are the @BATCH and @START system commands.

The @BATCH command has the following form.

@BATCH <SPEC>, <DATA>, RMENGR

where <SPEC> is the absolute module to be executed, and <DATA> is the name of the cataloged data file containing the input data. This command is relatively simple; but, it will cause the output of the analysis program to be printed on one of the system's higher speed printers. Since there is no means of redirecting the program output to a data file this command should be used only by those users who have ready access to University of Maryland physical facilities.

The START- command on the other hand allows the user more flexibility; but, at the price of having to construct a file containing the run stream images required to perform the required task. The form of the command is:

@START <spec>

where <spec> is the name of an element or a file containing run stream images. The START- command simply inserts a file containing run stream images in the batch queue; the user must define the run stream images required to control the computer data management and execution.

For example, assume that we had generated a data file "INPUT" using the IDP for the analysis program SAPIII. We would like to execute the SAPIII program and redirect the output to the file OUT which you could inspect at some later time using the text editor.

We would begin by first cataloging the file which will contain the run-stream images; let us call this file RUNIT., then we input the following system commands:

```
@CAT,U RUNIT
@FREE, RUNIT.
@ASG,A RUNIT.
```

Next, we will use the editor to enter the run stream images into RUNIT:

```
@ED RUNIT.
#RUN  <RUNID>, <ACCT NO>, <PROJECT I.D.>, <TIME>, <Pages>
#ASG,U ØUT                    (catalog the output file)
#FREE ØUT.
#ASG,A ØUT.
#BRKPT PRINT$/ØUT             (redirect the output)
#XQT  SYMPOSIUM*PROGRAM.SAPIII      (execute SAPIII)
#ADD <qualifier>*INPUT.       (add the data file)
#FIN           (required to terminate this job)
(C-R)          (carriage-return to enter edit mode)
```

We would now be in the "EDIT"-mode. Note that each of the control statements has been preceeded by a #-Sign rather than an @-sign. This was done because the @-sign would have caused the control to return to the system. We will therefore change the # to an @-sign and list the file at the same time by the editing commands;

T - go to the top of the file

C,* /#/@/ - change the # to @ in every line in the file

To exit the editor we now enter

E - end the edit session

The required submission can now be accomplished by the system command

@START RUNIT.

2.3.9. Printing File Contents

A hard copy of the file contents can be obtained by using a system command to request that it be printed on a high-speed printer. The command is:

@SYM <SPEC>,, RMENGR

The file "OUT" created by the analysis program SAPIII could be printed by the command

@SYM OUT.,, RMENGR

3. Program Function

3.1. Input Data Processors

The input data preprocessors (IDP) are computer programs that are normally executed in the demand mode and which allow the user to create an input data file for the appropriate analysis program. The preprocessors operate in either of two modes; prompting or data file.

In the prompting mode the IDP carries on a dialogue with the user; it asks for input data sets, and defines the input data items. The IDP then writes a formated output file which is the input file for the appropriate analysis program.

In tne data file mode the user preprepares the responses to the IDP prompting requests in a data file or data element using the text editor (see Section 2.3.6). The user then executes the IDP and in response to the request, "Do you want to enter data from a data file", responds "yes". The IDP will then request the name of the data file or element that contains the input data file. The IDP input will then be read from this file without the prompting that is associated with the interactive mode. The system may be directed to read the responses to the IDP prompting from a precreated data file by using the command

    @ADD <spec>

where <spec> is the name of the data file or element.

The IDP's presented by this symposium generally lack the capability of recovering from a data transmission error. Such an error, which may be due to a data generation error or problem in long distance communications lines, will cause a normal exit from the IDP. The only option available to the user is that of re-executing the program. Prior to re-executing, the data file that was created in the previous execution should be deleted by means of the system command:

    @DELETE FILENAME.

The use of the prompting mode seems most desirable as: a teaching device to help the user determine the sequence and type of data required; as a means of inputting unformatted input; and, as a means of checking data prior to execution of the analysis program. The more normal usage would seem to be that of the data file mode. If the attempted execution of the IDP in the data file mode leads to an undecipherable error message it is suggested that the prompting mode be utilized with the data file @ADD'ed to the run stream. This will cause the IDP to print all prompting but to read the input from the data file. This may assist the user in determining the incorrect entries in the data file.

3.2. Analysis Programs

The analysis programs are executable in either the batch or demand environments; subject to site core size limitations. The input data for the programs may be prepared by means of the appropriate IDP; or in the case of a program which requires a formatted input file and for which no IDP has been created, by means of the text editor.

If the program is executed in the demand mode the data file is added to the input data stream by means of an @ADD <SPEC> - command. This command causes the EXEC8 system to use the <spec>- file for input rather than the normal system input device.

The analysis program output will normally be returned to the terminal device. In the case of one of the small special purpose analysis programs this may be acceptable. However, the output associated with most of the larger programs is quite extensive so that some means of redirecting the program output is desirable. This feature called "Breakpointing" is discussed in section 2.3.7. You should

carefully note that once the output has been redirected, all computer responses will be written on that file until the system has been informed to do otherwise. The command @BRKPT PRINT$ must be given to direct the output back to the terminal.

The analysis program may be sufficiently large that it cannot be executed in the demand mode; or, requires more execution time than is reasonable for demand submission. In this case the job should be submitted to the batch queue using the system commands discussed in section 2.3.8.2

4.0 SAP - Structural Analysis Program

4.1 *Introduction*

SAP III, A Structural Analysis Program for Static and Dynamic Response of Linear Systems is described in reference (4). The analysis program is executed on the Univac 1108 under control of the EXEC8 operating system using single precision arithmetic.

The program has the following analysis capability:

1. Static Analysis
2. Natural Modes and Frequencies
3. Modal Response Spectrum
4. Modal Dynamic Response

The structural systems to be analyzed may be composed of combinations of a number of different structural elements. The program presently contains the following element types:

1. three-dimensional truss element
2. three-dimensional beam element
3. plane stress and plane strain element
4. two-dimensional axisymmetric solid
5. three-dimensional solid
6. thick shell element
7. thin plate or thin shell element
8. boundary element
9. pipe element (tangent and bend)

The program capabilities and theoretical basis are described in reference (4). The purpose of this section of the report is to describe (1) the IDP which

generates the formated input file for SAPIII; and (2) execution of the SAPIII IDP and analysis programs on the University of Maryland Univac 1108.

4.2 SAPIII Input Data Preprocessor

The SAPIII IDP operates in the Demand mode and allows the user to supply unformated input data in a program-controlled logical sequence. The IDP then performs some elementary checks and writes a file which contains the formated SAPIII input. The IDP executes in either of two modes, interactive or data file.

In the interactive mode the user supplies the required data in response to program-generated prompting. In the data file mode the user prepares a file containing the IDP input in exactly the same sequence as that required by the interactive mode. The IDP then by-passes all interactive responses and reads the data from the pre-prepared file. In either input mode the preprocessor will print a summary of the SAPIII data. The summary data is obtained by reading the FORMAT'ed SAPIII input file created by the IDP; and, thus provides a means of checking the correctness of this file.

The IDP logically omits requesting redundent input data; and, logically will not print redundent information in the output summary. Thus, if the user has specified the static option, the IDP will not request parameters which pertain only to the dynamic analysis. The IDP will insert all required data including blank card images in the SAPIII input file.

The input data items required by the SAP preprocessor are shown by Table 4.1. This data may be entered under IDP in the interactive mode; or a data file may be created and referenced by appropriate response to IDP interrogation as described by section 3.1.

4.2.1. Interactive mode

In the interactive mode the IDP describes the input data requirements so that the experienced user may describe a physical problem in terms of SAPIII parameters with little or no reference to the SAPIII user's manual. It is highly recommended that the inexperienced analyst use the interactive mode in conjunction with the SAPIII manual. The user will note that the IDP generally has the same variable names as those given in the SAPIII manual; and, that the logical sequence of input is the same.

In either mode the IDP requests the name that the user wishes to assign to the IDP output file. Upon termination of the IDP the named file will contain the formatted input data file for the SAPIII analysis program. This file is cataloged under the users' account number as a private file. The non-1108 user should note that the entire file name is:

QUALIFIER*NAME

Where the qualifier is that which was generated at sign-on time.

The user may enter the file name in full including any qualifier and read and write keys as follows:

QUALIFIER*NAME/KEY1/KEY2

Where KEY1 is a write key

KEY2 is a read key

The user is cautioned to retain these keys in a secure place, if provided; especially if a CRT terminal is used.

4.2.2. Data File (non-prompting mode)

In this mode the analyst prepares a data file containing the data described by Table 4.1. The elements of the data file are read by the IDP in the same logical sequence used by the interactive mode. In the data file mode the prompting is bypassed.

4.2.3. Description of IDP Input Requirements

The data elements defined on Table 4.1 are generally given the same names as those found in the SAP users manual; and, the user is directed to either the users manual, reference (4), or to the interactive execution of the program for their description.

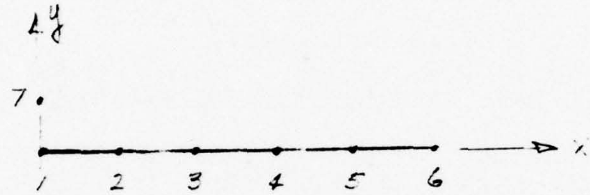
There are some differences between the SAPIII batch program input requirements, and the data set requested by the IDP. These are:

1. Data which applies to the dynamic analysis are not requested if the number of loads (LL) is greater than zero.
2. Data which describes element loads are not requested if the dynamic option (LL.EQ.0) is chosen.
3. Element loads can be set to zero by answering "yes" to an appropriate program query.
4. Node data input terminates when the node number equals the total number of nodes, NUMNP.
5. Element data terminates when the element number equals the total number of elements specified in a group.
6. The user may specify an isotropic material for the shell element; the preprocessor then calculates the material stiffness matrix.
7. All data must be entered correct as to type; i.e. real numbers must have decimal point. The normal FORTRAN convention for variable types is followed, except as noted in the variable description which is given by the interactive mode.
8. Numerical codes are used in place of holorith data for
   (a) Node point coordinate system specification.
   (b) Connect and Load data for pipe element.

4.2.4. Example - Uniformly Loaded Cantilever Beam

Consider the problem of a beam subject to a uniform load as shown below

We chose to descretize the beam as shown.



Because of the structural topology we can use both node point and element generation features of the SAP-program. Node point data for nodes 2 through 6 will be automatically generated by the analysis program if on the data associated with node 2,KN=0 and for node 6, KN=1.

Similarly the element data for elements 1 through 5 may be generated by setting KN=1 on the input data for element 1.

4.2.4.1 Interactive Mode

Before calling for execution of the preprocessor we note that:

(1) NUMNP = 7
NETYP = 1
LL = 1
MODEX = 0
KEQB = 0

(2) Rectangular Coords will be used

(3) That node 1 and 7 are fully fixed;
that nodes 2 through 6 must have degrees of freedom numbers 1, 3, 4 and 5 constrained in order to make the stiffness matrix nonsingular
that node 7 is required to define the local X-Y plane

(4) The distributed load must be modeled using either fixed end forces or concentrated nodal forces - we choose to use the fixed end forces

The interactive preprocessor execution is as follows, where the user responses to program or system requests are underlined.

```
@XQT SYMPOSIUM*PREPROCESSOR.SAP

                         ***** TS0006*****

                INPUT DATA PREPROCESSOR FOR S.A.P.

 UNIVAC 1100-SERIES VERSION. INPUT DATA IS TO BE ENTERED FROM EITHER
 THE INTERACTIVE OR THE DATA FILE MODE USING FREE FORM INPUT AS
 DESCRIBED IN THE UNIVAC FORTRAN V MANUAL. IN THIS MODE THE
 INDIVIDUAL ELEMENTS OF THE DATA SET ARE SEPARATED BY COMMAS (,).
 NOTE THAT THE DECIMAL POINT (.) IS REQUIRED FOR REAL NUMBERS. THE
 NORMAL FORTRAN CONVENTION IS FOLLOWED FOR VARIABLE NAMES UNLESS
 OTHERWISE INDICATED BY APPENDING AN ANNOTATION TO THE VARIABLE
 DESCRIPTION

 ENTER NAME OF OUTPUT DATA FILE
SAPIN

 DO YOU WANT TO ENTER DATA FROM A DATA FILE (YES OR NO)
NO

 ENTER TITLE (NOT TO EXCEED 72 CHARACTERS)
UNIFORMLY LOADED CANTILEVERED BEAM

            -MASTER CONTROL INFORMATION-

 ENTER THE DATA SET (NUMNP,NELTYP,LL,MODEX,KEQB) WHERE:
     NUMNP =NUMBER OF NODES
     NELTYP=NUMBER OF ELEMENT TYPES
     LL      NUMBER OF STRUCTURAL LOADS
             .GE.1 STATIC LOAD CASE
             .EQ.0 DYNAMIC LOAD CASE
     MODEX   PROGRAM EXECUTION MODE
             .EQ.0 PROBLEM SOLUTION
             .EQ.1 DATA CHECK ONLY
     KEQB    SET EQUAL TO ZERO (SEE NOTE 8)
7,1,1,0,0
```

```
            -NODAL POINT DATA-

 ENTER SUFFICIENT DATA SETS OF THE FOLLOWING FORM TO DEFINE  7 NODES
 (IC,N,(IX(N,I),I=1,6),X,Y,Z,KN,T) WHERE:
      IC IS A COORD CODE
              .EQ.1 RECTANGULAR
              .EQ.2 CYLINDRICAL
      N =NODE NUMBER
      IX=FIXITY CODE FOR D.O.F (I)
              .EQ.0 NO CONSTRAINT ON D.O.F (I)
              .EQ.1 D.O.F (I) CONSTRAINED
      (X,Y,Z) COORDS OF NODE N
      KN=NODE DATA GENERATION CODE
      T =TEMPERATURE
1,1,1,1,1,1,1,1,0.,0.,0.,0,0.
1,2,1,0,1,1,1,0,2.,0.,0.,0,0.
1,6,1,0,1,1,1,0,10.,0.,0.,1,0.
1,7,1,1,1,1,1,1,0.,1.,0.,0,0.


            -ELEMENT DATA-

 ELEMENT DATA MUST BE SPECIFIED FOR  1 ELEMENT GROUPS


 ENTER DATA SET (NTYPE,NELMT,NMAT) FOR GROUP  1 WHERE:
      NTYPE= ELEMENT TYPE
      NELMT=NO OF ELMTS IN GROUP
      NMAT =NO OF MATERIAL PROPERTIES
2,5,1


        -THREE DIMENSIONAL BEAM ELEMENT-

 ENTER THE DATA SET (NPROP,NFIX) WHERE:
      NPROP=NUMBER OF PROPERTY SETS
      NFIX =NUMBER OF FIXED-END FORCES
1,0


 ENTER  1 MATERIAL CARDS OF THE FORM (MID,E,NU,RHO,WT) WHERE:
      MID =MATERIAL I.D.
      E   =MODULUS OF ELASTICITY
      NU  =POISSONS RATIO
      RHO =MASS DENSITY
      WT  =WEIGHT DENSITY
1,1.E7,.3,0.,0.
```

```
 ENTER  1 PROPERTY CARDS OF THE FORM (PID,AREA,SHR2,SHR3,ITOR,I2,I3)
 WHERE:
      PID =PROPERTY I.D. (INTEGER)
      AREA=AXIAL AREA
      SHR2=SHEAR AREA IN LOCAL 2-DIRECTION
      SHR3=SHEAR AREA IN LOCAL 3-DIRECTION
      ITOR=TORSIONAL CONSTANT (REAL)
      I2  =FLEXURAL INERTIA ABOUT 2-DIRECTION (REAL)
      I3  =FLEXURAL INERTIA ABOUT 3-DIRECTION (REAL)
1,1.,0.,0.,1.,1.,1.


 DO YOU WANT TO SET ALL ELEMENT LOAD FACTORS TO ZERO (YES OR NO)
YES


 BEAM CONNECTIVITY

 ENTER SUFFICIENT DATA SETS (NELM,I,J,K,MID,PID,IDA,IDB,IDC,IDD,IREL,JRE
L,KG)
 TO DEFINE   5 ELEMENTS WHERE:
      NELM=ELEMENT NO.
      (I,J,K)-NODE NUMBERS
      MID =MATERIAL I.D.
      PID =PROPERTY I.D. (INTEGER)
      (IDA,IDB,IDC,IDD)-FIXED-END FORCE ID S FOR LOAD CASES (A,B,C,D)
      (IREL,JREL)-END RELEASE CODE
      KG  =ELEMENT GENERATION PARAMETER
 NOTE!!! DATA SET FOR LAST ELEMENT MUST BE DEFINED
1,1,2,7,1,1,0,0,0,0,0,0,1
5,5,6,7,1,1,0,0,0,0,0,0,0


          -CONCENTRATED LOAD/MASS DATA

 ENTER THE DATA SET (N,L,FX,FY,FZ,MX,MY,MZ) WHERE:
      N   =NODE NO.
      L   =STRUCTURAL LOAD CASE
      (FX,FY,FZ) - FORCES OR TRANSLATIONAL MASSES
      (MX,MY,MZ) - MOMENTS OR ROTARY INERTIAS (REAL)

 TERMINATE WITH A ZERO DATA SET
2,1,0.,.2,0.,0.,0.,0.,-
3,1,0.,.2,0.,0.,0.,0.
4,1,0.,.2,0.,0.,0.,0.
5,1,0.,.2,0.,0.,0.,0.
6,1,0.,.2,0.,0.,0.,0.
0,0,0.,0.,0.,0.,0.,0.
```

```
            -ELEMENT LOAD MULTIPLIERS-

 ENTER  1 DATA SETS (ELM(I),I=1,4) WHERE ELM(I) ARE THE LOAD
 FACTORS FOR LOAD CASES (A,B,C,D)
0.,0.,0.,0.


 DO YOU WANT A SUMMARY OF THE SAP INPUT DATA (YES OR NO )
YES


                  **** INPUT DATA SUMMARY FOR S.A.P. ****


 NIFORMLY LOADED CANTILEVERED BEAM


            -MASTER CONTROL INFORMATION-

      NUMNP =     7
      NELTYP=     1
      LL    =     1
      NF    =     0
      NDYN  =     0
      MODEX =     0
      NAD   =     0
      KEQB  =     0


            -NODE POINT DATA-

 NODE COORD                COORDINATES              NODE   NODAL
  NO   ID        X1            X2           X3       INC  TEMPERATURE
  1            .0000         .0000        .0000       0     .0000
  2            .2000+01      .0000        .0000       0     .0000
  6            .1000+02      .0000        .0000       1     .0000
  7            .0000         .1000+01     .0000       0     .0000

 NODE  PERMANENT SINGLE POINT CONSTRAINTS
 NO    X1     X2     X3     R1     R2     R3
  1     1      1      1      1      1      1
  2     1      0      1      1      1      0
  6     1      0      1      1      1      0
  7     1      1      1      1      1      1

            -ELEMENT DATA-
```

-THREE-DIMENSIONAL BEAM ELEMENT-

NELMT= 5
NPROP= 1
NFEF = 0
NMAT = 1

MID	E	NU	RHO	WT
1	.100+08	.300	.000	.000

PID	AREA	SHEAR 1	SHEAR 2	J	I-22	I-33
1	1.00	.000	.000	1.00	1.00	1.00

GRAV		ELEMENT LOAD FACTORS		
DIR	CASE A	CASE B	CASE C	CASE D
X	.000	.000	.000	.000
Y	.000	.000	.000	.000
Z	.000	.000	.000	.000

BEAM DATA

ELMT NO	NODE I	NODE J	NODE K	MID	PID	FIXED-END A	FORCE B	I.D. C	D	CODE I	CODE J	GEN PARAM
1	1	2	7	1	1	0	0	0	0	0	0	1
5	5	6	7	1	1	0	0	0	0	0	0	0

-CONCENTRATED LOADS/MASSES-

NODE	LOAD		FORCES			MOMENTS	
NO	CASE	X	Y	Z	X	Y	Z
2	1	.000	.200+00	.000	.000	.000	.000
3	1	.000	.200+00	.000	.000	.000	.000
4	1	.000	.200+00	.000	.000	.000	.000
5	1	.000	.200+00	.000	.000	.000	.000
6	1	.000	.200+00	.000	.000	.000	.000

-ELEMENT LOAD MULTIPLIERS-

LOAD		ELEMENT MULTIPLIER		
NO	CASE A	CASE B	CASE C	CASE D
1	.000	.000	.000	.000

IS THERE AN ADDITION CASE (YES OR NO)
NO

NORMAL EXIT. EXECUTION TIME: 3258 MILLISECONDS.

4.2.4.2 Data File Mode

The input data for the data file mode is to be stored in an element called "EXAMPLE1". The editing session used to create this file is as follows:

```
@ED EXAMPLE1
ED 28C 03/14-11:29-(00):F
INPUT
 CANTILEVERED BEAM WITH UNIFORM LOADING
7,1,1,0,0
1,1,1,1,1,1,1,1,0.,0.,0.,0,0.
1,2,1,0,1,1,1,0,.2,0.,0.,0,0.
1,6,1,0,1,1,1,0,10.,0.,0.,1,0.
1,7,1,1,1,1,1,1,0.,1.,0.,0,0.
2,5,1
1,0
1,1.E7,.3,0.,0.
1,1.,0.,0.,1.,1.,1.
YES
1,1,2,7,1,1,0,0,0,0,0,0,1
1,?
5,5,6,7,1,1,0,0,0,0,0,0,0
2,1,0.,.2,0.,0.,0.,0.
3,1,0.,.2,0.,0.,0.,0.
4,1,0.,.2,0.,0.,0.,0.
5,1,0.,.2,0.,0.,0.,0.
6,1,0.,.1,0.,0.,0.,0.,-
0,0,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.
YES
NO
```

After verifying that the data file is correct. The IDP is executed using the element EXAMPLE1 as follows:

```
@XQT SYMPOSIUM*PREPROCESSOR.SAP

                         ***** TS0006*****

                 INPUT DATA PREPROCESSOR FOR S.A.P.

 UNIVAC 1100-SERIES VERSION. INPUT DATA IS TO BE ENTERED FROM EITHER
 THE INTERACTIVE OR THE DATA FILE MODE USING FREE FORM INPUT AS
 DESCRIBED IN THE UNIVAC FORTRAN V MANUAL. IN THIS MODE THE
 INDIVIDUAL ELEMENTS OF THE DATA SET ARE SEPARATED BY COMMAS (,).
 NOTE THAT THE DECIMAL POINT (.) IS REQUIRED FOR REAL NUMBERS. THE
 NORMAL FORTRAN CONVENTION IS FOLLOWED FOR VARIABLE NAMES UNLESS
 OTHERWISE INDICATED BY APPENDING AN ANNOTATION TO THE VARIABLE
 DESCRIPTION


 ENTER NAME OF OUTPUT DATA FILE
SAPIN


 DO YOU WANT TO ENTER DATA FROM A DATA FILE (YES OR NO)
YES


 ENTER NAME OF INPUT  DATA FILE
EXAMPLE1

                **** INPUT DATA SUMMARY FOR S.A.P. ****

 CANTILEVERED BEAM WITH UNIFORM LOADING

          -MASTER CONTROL INFORMATION-

     NUMNP =     7
     NELTYP=     1
     LL    =     1
     NF    =     0
     NDYN  =     0
     MODEX =     0
     NAD   =     0
     KEQB  =     0
```

-NODE POINT DATA-

NODE NO	COORD ID	COORDINATES X1	X2	X3	NODE INC	NODAL TEMPERATURE
1		.0000	.0000	.0000	0	.0000
2		.2000+00	.0000	.0000	0	.0000
6		.1000+02	.0000	.0000	1	.0000
7		.0000	.1000+01	.0000	0	.0000

NODE NO	PERMANENT SINGLE POINT CONSTRAINTS X1	X2	X3	R1	R2	R3
1	1	1	1	1	1	1
2	1	0	1	1	1	0
6	1	0	1	1	1	0
7	1	1	1	1	1	1

-ELEMENT DATA-

-THREE-DIMENSIONAL BEAM ELEMENT-

NELMT= 5
NPROP= 1
NFEF = 0
NMAT = 1

MID	E	NU	RHO	WT
1	.100+08	.300	.000	.000

PID	AREA	SHEAR 1	SHEAR 2	J	I-22	I-33
1	1.00	.000	.000	1.00	1.00	1.00

GRAV DIR	ELEMENT LOAD FACTORS CASE A	CASE B	CASE C	CASE D
X	.000	.000	.000	.000
Y	.000	.000	.000	.000
Z	.000	.000	.000	.000

BEAM DATA

ELMT NO	NODE I	NODE J	NODE K	MID	PID	FIXED-END FORCE I.D. A	B	C	D	CODE I	CODE J	GEN PARAM
1	1	2	7	1	1	0	0	0	0	0	0	1
5	5	6	7	1	1	0	0	0	0	0	0	0

-CONCENTRATED LOADS/MASSES-

NODE	LOAD	FORCES			MOMENTS		
NO	CASE	X	Y	Z	X	Y	Z
2	1	.000	.200+00	.000	.000	.000	.000
3	1	.000	.200+00	.000	.000	.000	.000
4	1	.000	.200+00	.000	.000	.000	.000
5	1	.000	.200+00	.000	.000	.000	.000
6	1	.000	.100+00	.000	.000	.000	.000

NO

-ELEMENT LOAD MULTIPLIERS-

LOAD	ELEMENT MULTIPLIER			
NO	CASE A	CASE B	CASE C	CASE D
1	.000	.000	.000	.000

NORMAL EXIT. EXECUTION TIME: 3397 MILLISECONDS.
DATA IGNORED - IN CONTROL MODE

4.2.4.3. Formatted SAP Input File

The formatted SAP input file may be listed by means of the text editor. The session required to list the output file, SAPIN is shown below.

```
@ED SAPIN.
ED 28C 03/14-11:15-(00):F
EDIT
*P 50

UNIFORMLY LOADED CANTILEVERED BEAM
    7    1    1    0    0    0    0    0
    1    1    1    1    1    1    1  .000      .000      .000      0
 .000
    2    1    0    1    1    1    0  2.00      .000      .000      0
 .000
    6    1    0    1    1    1    0  10.0      .000      .000      1
 .000
    7    1    1    1    1    1    1  .000      1.00      .000      0
 .000
    2    5    1    0    1
    1   .100+08   .300      .000      .000
    1   1.00      .000      .000      1.00      1.00      1.00
   .000      .000      .000      .000
   .000      .000      .000      .000
   .000      .000      .000      .000
    1    1    2    7    1    1    0    0    0    0    0    0    1
    5    5    6    7    1    1    0    0    0    0    0    0    0
    2    1  .000      .200      .000      .000      .000      .000
    3    1  .000      .200      .000      .000      .000      .000
    4    1  .000      .200      .000      .000      .000      .000
    5    1  .000      .200      .000      .000      .000      .000
    6    1  .000      .200      .000      .000      .000      .000
    0    0  .000      .000      .000      .000      .000      .000
   .000      .000      .000      .000
EOF AT LINE 21
*G 19
    6    1  .000      .200      .000      .000      .000      .000
*C /.2/.1/
    6    1  .000      .100      .000      .000      .000      .000
*E
END EDIT 21 LINES OUTPUT
```

4.3. SAP-Analysis Program

The SAP analysis program can be executed in either of two modes, both of which utilize the formatted input data file produced by the IDP. The SAP analysis program can be executed in the "Demand" mode for small-to-intermediate sized problems; and, for large problems may be submitted to the "Batch" queue. The only important difference in the two modes is that the user is free to perform other tasks on the terminal if the batch mode is utilized.

4.3.1. Demand Mode

The SAP analysis program is executed by entering the following system commands from the TTY;

```
@XQT SYMPOSIUM*PROGRAM.SAPIII
@ADD <SPEC>
```

where <SPEC> is the name of the input file which was created by the preprocessor.

4.3.2. Batch Mode

The SAP program may be submitted to the "batch" queue by the command

```
@BATCH  SYMPYPOSIUM*PROGRAM.SAPIII, <data> , RMENGR
```

where

<data> is the name of the data file

created with the preprocessor.

4.3.3. Redirecting Output

You may choose to have the program output saved on a cataloged file in either the demand or batch mode. In this case you must

(1) Catalog a file

(2) Inform the system to redirect output

(3) Execute the program

(4) If on demand, inform system to direct output to TTY after execution

The basic commands necessary to perform steps (1), (2) and (4) are given in section 2.

The third step depends on the mode of operation. The following are examples of run stream controls for both modes.

4.3.3.1. Demand

```
@CAT, U SAPOUT
@FREE SAPOUT.
@BRKPT PRINT$/SAPOUT
@XQT SYMPOSIUM*PROGRAM.SAPIII
@ADD SAPIN.
@BRKPT PRINT$
```

At this point control would be returned to the remote terminal, and the SAP-output could be examined using the text editor.

4.3.3.2 Batch

In order to redirect the output to a cataloged file in the batch mode we must create a procedure file and use the system command @START rather than @BATCH to submit the job to the batch queue as indicated in section 2.3.8.2. The procedure file is created using the text editor. In the example shown below the file START is created which contains the required run stream card-images. These images are then submitted to the batch queue by the command @START START.

```
@ASG,U START,F              (assign file "START")
@ED START.                  (use editor to create file)
#RUN <RYBUD>,  <ACCOUNT NO>, <PROJECT>, <TIME>, <PAGES>
#CAT,U SAPOUT,F
#FREE SAPOUT.
#BRKPT PRINT$/SAPOUT
```

```
#XQT SYMPOSIUM*PROGRAM.SAPIII
#ADD SAPIN.
#FIN
C-R      (Return to edit mode)
#C,* /#/@/   (change #'s to @'s)
@START START.
```

Note that @-signs cannot be entered directly in the editor input mode. The #'s have thus been entered in place of the @-sign and the editor has been utilized to change # to @.

4.3.4. Scanning the output

The text editor may be used to scan the output by entering

```
@ED SAPOUT.
```

The displacements may be found by

```
L DIST
```

The forces may be found by

```
L FORCE
```

The lines of text following the selected current line may be printed by

```
O NL
```

Where NL is the number of lines to be printed.

4.3.5. Printing Output

The output may be printed on the high-speed printer by entering

```
@SYM SAPOUT.,,RMENG
```

If you do so, and wish to have the output mailed you must use the text editor to enter your name and mailing address in the output file.

4.3.6. Analysis Program Output.

The output of the SAP-analysis program for the example problem is as follows.

CANTILEVERED BEAM WITH UNIFORM LOADING

C O N T R O L   I N F O R M A T I O N

```
    NUMBER OF NODAL POINTS      =     7
    NUMBER OF ELEMENT TYPES     =     1
    NUMBER OF LOAD CASES        =     1
    NUMBER OF FREQUENCIES       =     0
    ANALYSIS CODE (NDYN)        =     0
      EQ.0,  STATIC
      EQ.1,  MODAL EXTRACTION
      EQ.2,  FORCED RESPONSE
      EQ.3,  RESPONSE SPECTRUM
    SOLUTION MODE (MODEX)       =     0
      EQ.0,  EXECUTION
      EQ.1,  DATA CHECK
```

NODAL POINT INPUT DATA

NODE	BOUNDARY CONDITION CODES							NODAL POINT COORDINATES			
NO.	X	Y	Z	XX	YY	ZZ	X	Y	Z		T
1	1	1	1	1	1	1	.000	.000	.000	0	.000
2	1	0	1	1	1	0	.200	.000	.000	0	.000
6	1	0	1	1	1	0	10.000	.000	.000	1	.000
7	1	1	1	1	1	1	.000	1.000	.000	0	.000

GENERATED NODAL DATA

NODE	BOUNDARY CONDITION CODES						NODAL POINT COORDINATES			
NO.	X	Y	Z	XX	YY	ZZ	X	Y	Z	T
1	1	1	1	1	1	1	.000	.000	.000	.000
2	1	0	1	1	1	0	.200	.000	.000	.000
3	1	0	1	1	1	0	2.650	.000	.000	.000
4	1	0	1	1	1	0	5.100	.000	.000	.000
5	1	0	1	1	1	0	7.550	.000	.000	.000
6	1	0	1	1	1	0	10.000	.000	.000	.000
7	1	1	1	1	1	1	.000	1.000	.000	.000

EQUATION NUMBERS

N	X	Y	Z	XX	YY	ZZ
1	0	0	0	0	0	0
2	0	1	0	0	0	2
3	0	3	0	0	0	4
4	0	5	0	0	0	6
5	0	7	0	0	0	8
6	0	9	0	0	0	10
7	0	0	0	0	0	0

```
.......THREE DIMENSIONAL BEAM ELEMENTS

 NUMBER OF BEAMS                      =      5
 NUMBER OF GEOMETRIC PROPERTY SETS=          1
 NUMBER OF FIXED END FORCE SETS       =      0
 NUMBER OF MATERIALS                  =      1
```

MATERIAL	YOUNG S MODULUS	POISSON S RATIO	MASS DENSITY	
1	10000000.	.30000	.00000	.00000

BEAM GEOMETRIC PROPERTIES

ELMT TYPE	AREA X	AREA Y	AREA Z	INERTIA X	INERTIA Y	INERTIA Z
1	1.000	.000	.000	1.000	1.000	1.000

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X-DIR	.000000	.000000	.000000	.000000
Y-DIR	.000000	.000000	.000000	.000000
Z-DIR	.000000	.000000	.000000	.000000

BEAM NO	NODES I	J	K	MATL NO	GEOM NO	ELEM LOADS A	B	C	D	END CODES I	J
1	1	2	7	1	1	0	0	0	0	0	0
2	2	3	7	1	1	0	0	0	0	0	0
3	3	4	7	1	1	0	0	0	0	0	0
4	4	5	7	1	1	0	0	0	0	0	0
5	5	6	7	1	1	0	0	0	0	0	0

E Q U A T I O N   P A R A M E T E R S

TOTAL NUMBER OF EQUATIONS	=	10
BANDWIDTH	=	4
NUMBER OF EQUATIONS IN A BLOCK	=	10
NUMBER OF BLOCKS	=	1

..... NODAL FORCES/MOMENTS

NODE NO.	LOAD CASE	X-AXIS FORCE	Y-AXIS FORCE	Z-AXIS FORCE	X-AXIS MOMENT	Y-AXIS MOMENT	Z-AXIS MOMENT
2	1	.000	.200+00	.000	.000	.000	.000
3	1	.000	.200+00	.000	.000	.000	.000
4	1	.000	.200+00	.000	.000	.000	.000
5	1	.000	.200+00	.000	.000	.000	.000
6	1	.000	.100+00	.000	.000	.000	.000

STRUCTURE LOAD CASE	ELEMENT LOAD MULTIPLIERS A	B	C	D
1	.000	.000	.000	.000

N O D E   D I S P L A C E M E N T S / R O T A T I O N S

NODE NO.	LOAD CASE	X- TRNSLTN	Y- TRNSLTN	Z- TRNSLTN	X- ROTATION	Y- ROTATION	Z- ROTATION
7	1	.0000	.0000	.0000	.0000	.0000	.0000
6	1	.0000	.1040-04	.0000	.0000	.0000	.1401-05
5	1	.0000	.9995-05	.0000	.0000	.0000	.1371-05
4	1	.0000	.3783-05	.0000	.0000	.0000	.1221-05
3	1	.0000	.1209-05	.0000	.0000	.0000	.8305-06
2	1	.0000	.9080-09	.0000	.0000	.0000	.8020-07
1	1	.0000	.0000	.0000	.0000	.0000	.0000

.....BEAM FORCES AND MOMENTS

BEAM NO.	LOAD NO.	AXIAL R1	SHEAR R2	SHEAR R3	TORSION M1	BENDING M2	BENDING M3
1	1	.000	-.900+00	.000	.000	.000	-.410+01
		.000	.900+00	.000	.000	.000	.392+01
2	1	.000	-.700+00	.000	.000	.000	-.392+01
		.000	.700+00	.000	.000	.000	.220+01
3	1	.000	-.500+00	.000	.000	.000	-.220+01
		.000	.500+00	.000	.000	.000	.980+00
4	1	.000	-.300+00	.000	.000	.000	-.980+00
		.000	.300+00	.000	.000	.000	.245+00
5	1	.000	-.100+00	.000	.000	.000	-.245+00
		.000	.100+00	.000	.000	.000	-.119-05

S T A T I C   S O L U T I O N   T I M E   L O G

```
EQUATION SOLUTION    =     .04
DISPLACEMENT OUTPUT  =     .07
STRESS RECOVERY      =     .18
```

O V E R A L L   T I M E   L O G

NODAL POINT INPUT	=	.14
ELEMENT STIFFNESS FORMATION	=	.32
NODAL LOAD INPUT	=	.08
TOTAL STIFFNESS FORMATION	=	.17
STATIC ANALYSIS	=	.30
EIGENVALUE EXTRACTION	=	.00
FORCED RESPONSE ANALYSIS	=	.00
RESPONSE SPECTRUM ANALYSIS	=	.00
TOTAL SOLUTION TIME	=	1.00

Table 4.1-SAP Preprocessor Input Data Elements

I. 72 Column Title

II. (NUMNP,NELTYP,LL,MODEX,KEQB)

If LL.LE.0 Go to IIA

GT.0 Go to III

IIA. (NF,KDYN,ND)

III. Data Sets

(IC,N,IX(1 6),(X,Y,Z),KN,T)

MUST END WITH N=NUMNP

IV. (NTYPE,NELMT,NMAT)

A NON-ZERO ENTRY FOR NMAT REQUIRED FOR ALL ELMT. TYPES

IV.1 FOR NTYPE.EQ.1 IV.1

.A NMAT SETS (MID,E,α,ρ,A,γ)

.B SKIP IF LL.EQ.0

YES IF ALL ELMT LOADS ARE ZERO

4 SETS (A,B,C,D) OTHERWISE

.C DATA SETS

(NEL,I,J,MID,T,K)

MUST END WITH NEL=NELMT

IV.2 FOR NTYPE.EQ.2

.A (NPROP,NFIX)

.B NMAT SETS (MID,E,ν,ρ,γ)

.C NPROP SETS (PID,A,SA2,SA3,J,I22,I33)

.D SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

3 SETS (A,B,C,D)OTHERWISE

TABLE 4-1 (continued)

.E SKIP IF NFIX.EQ.0

NFIX SETS (NFIX,FEFATI(1 6),FEFATJ(1 6))

.F DATA SETS (NELM,I,J,K,MID,PID,IDA,IDB,IDC,IDD,IREL,JREL,KG)

MUST END WITH NELM=NELMT

IV.3 FOR NTYPE.EQ.3

.A (NTEMP,MODE)

.B NMAT SETS AS FOLLOWS:

.B.1 (MID,NTEMP,γ,ρ,β)

.B.2 NTEMP DATA SETS (T,E_n,E_s,E_t,ν_{ns},ν_{nt},ν_{st},G_{ns},α_n,α_s,α_t)

.C SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

4 SETS (TL,PL,XL,YL,ZL) OTHERWISE

.D DATA SETS (NEL,I,J,K,L,MID,TREF,PRES,OP,KG,T)

MUST END WITH NEL=NELMT

IV.4 FOR NTYPE.EQ.4

.A (NTEMP,NOPT,MODE)

.B.1 (MID,NTEM,γ,ρ,β)

.B.2 NTEM SETS (T,E_n,E_s,E_t,ν_{ns},ν_{nt},ν_{st},G_{ns},α_n,α_s,α_t)

.C SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

4 SETS (TL,PL,XL,YL,ZL) OTHERWISE

.D DATA SETS (NEL,I,J,K,L,MID,TREF,PRES,NOP,KG,T)

MUST END WITH NEL=NELMT

IV.5 FOR NTYPE.EQ.5

.A LS

.B NMAT SETS (MID,E,ν,γ,α)

TABLE 4-1 (continued)

.C SKIP IF LS.EQ.0

LS SETS (LID,LT,P,Y,NFACE)

.D G

.E SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

5 DATA SETS (A,B,C,D) OTHERWISE

.F DATA SET (EID,NODES(1→8),IO,MID,INC,LS(1→4),FACE(1,2),T)

MUST END WITH EID=NELMT

IV.6 FOR NTYPE.EQ.6

.A ANSWER TO "IS MATERIAL ISOTROPIC?"

.A.1 YES, NMAT SETS (MID,ρ,α,E,ν) $.0 \leq \nu \leq .5$

.A.2 NO, NMAT SETS ($MID,\rho,\alpha_x,\alpha_y,\alpha_z,C_{xx},C_{xy},C_{xs},C_{yy},C_{ys},C_{xy}$)

.B SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

5 DATA SETS (A,B,C,D) OTHERWISE

.C DATA SETS (NEL,I,J,K,L,NO,MID,KG,T,PRESS,TEMP,GRAD)

MUST END WITH NEL=NELMT

IV.7 FOR NTYPE.EQ.7

.A SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

DATA SET (A,B,C,D) OTHERWISE

.B DATA SETS (NODE,I,J,K,L,ID,IR,KN,DISP,ROT,STIFF)

LAST ELMT MUST BE DEFINED

IV.8 FOR NTYPE.EQ.8

.A NL

.B NMAT SETS (MID,E,NU,γ,α)

.C SKIP IF NL,EQ.0

NL DATA SETS (LID,LT,P,Y,NFACE)

TABLE 4-1 (continued)

.D (TREF,G)

.E SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

5 DATA SETS (A,B,C,D) OTHERWISE

.F DATA SETS (EID,IO,MID,INC,LS(1→4),T,NODE(1→16))

MUST END WITH EID=NELMT

IV.9 FOR NTYPE.EQ.9

.A (MAXTP,NSECT,NBRP,MAXTAN)

.B NMAT SETS AS FOLLOWS:

.B.1(M,NT)

.B.2 (LABEL(36 cols.))

.B.3 NT DATA SETS (T,E,ν,α)

.C NSECT SETS AS FOLLOWS:

.C.1 (N,D,T,SF,WT,RHO)

.C.2 (LABEL(18 cols.))

.D NBRP NODE NUMBERS

.E SKIP IF LL.EQ.0

YES IF ELMT LOADS ARE ZERO

5 DATA SETS (A,B,C,D) OTHERWISE

.F.1 DATA SETS (N,CODE,I,J,MID,SID,T,P,A_1,A_2,A_3,K)

.F.2 OMIT IF CODE.EQ.0 (R,CODE,X,Y,Z,F)

MUST END WITH N=NELMT

V. (N,L,FX,FY,FZ,MX,MY,MZ)

TERMINATE WITH ZERO SET

VI. SKIP IF LL.EQ.0

LL DATA SETS (A,B,C,D)

IF (LL.GT.0) ANSWERS TO FOLLOWING QUESTIONS, OTHERWISE PROCEED TO VII.

TABLE 4-1 (continued)

Q.1 "DO YOU WANT A SUMMARY OF SAP INPUT DATA?" (YES OR NO)

Q.2 "IS THERE AN ADDITIONAL CASE?" (YES OR NO)

VII. (IFNDYN,EQ.1,2, or 3) (IFSS,NITEM,RTOL,COFQ,NFO)

.A (NDYN.EQ.2 or 4)

.A.1 (NFN,NGM,NAT,NT,NOT,DT, & DAMP / ALPHA.BETA {IF (NDYN.EQ.2) / IF (NDYN.EQ.4)}

.A.2 SKIP IF (NFN.EQ.0) (N,IC,IFN,IAT,XM)

TERMINATE WITH A ZERO DATA SET

.A.3 SKIP IF NGM.EQ.0 (NFNX,NFN,Y,NFN,Z,NATX,NAT.Y.NAT.Z)

.A.4 SKIP IF NAT,EQ.0

NAT ARRIVAL TIMES (A(I),I=1,NAT)

.A.5.A NFN SETS

(NLP,SFTR)

HED (LE.60 COLS)

.A.5.B NLP PAIRS (T,F)

.A.6.A.1 (KKK,ISP)

.A.6.A.2 (N,IC(I),I=1,6)

TERMINATE WITH ZERO SET

.A.6.B.1 (KKK,ISP)

.A.6.B.2 (N,IS(I),I=1,12)

TERMINATE WITH A ZERO SET

Answer Q.1 and Q.2, above, to terminate dynamic input data

.B (NDYN.EQ.3)

5.0 VISCEL/ELAS - Viscoelastic Analysis of Linear Systems

5.1 Introduction

VISCEL, a general-purpose computer program for the analysis of linear viscoelastic structures is described in reference (5). This program contains the ELAS-program capability as a subset; and incorporates the basic ELAS input data set. The ELAS-program and input data are described by reference (6). The modifications to the basic ELAS input required to perform a viscoelastic analysis are described in reference (5).

The VISCEL and ELAS programs, together with program documentation, are available from COSMIC (7). The ELAS program is also maintained and distributed by its author; and, is available from the Duke University.

This report describes the execution of the (1) an interactive program which generates the formatted input file for VISCEL; and (2) the execution of the input data processor (IDP) and the VISCEL analysis program on the University of Maryland Univac 1108.

5.2 VISCEL/ELAS Input Data Preprocessor

The VISCEL IDP operates in the Demand mode and allows the user to input unformated data in a program-controlled logical sequence. The IDP performs some elementary error checks and writes a file which contains the formated input required by the VISCEL analysis program. The IDP operates in either of two modes, interactive or data file; and, further allows the user to control the amount of computer generated prompting in the interactive mode.

In the interactive mode the IDP issues prompting information which is displayed by the terminal device. The user then inputs the requested information directly by means of the keyboard in unformated form; i.e. the data elements

are delimited by commas. This interaction continues until all of the input requirements have been satisfied. In the data file mode the user prepares the unformatted input to the IDP; and, then informs the IDP the name of the data file. The IDP then reads the input data directly from the data file in exactly the same sequence as the interactive mode; but, completely bypasses the prompting information.

In either mode the sequence required for the IDP input is shown by Table 5.1. For the most part the input data elements have the same names and meaning as those variables defined in the program users manual. However it is recommended that the interactive mode be executed initially with maximum prompting in order to completely define each data element.

The user will note that the IDP does not request all of the program control information described in the ELAS/VISCEL users manuals. The IDP does not allow the use of externally prepared subroutines such as "CORG", "MESG", and "BUNG", nor does it allow the inclusion of data cards such as those required by the relabelling options, ISHUF = 2 or 3. The following parameters are preset in the IDP.

ITAP = 2

ITAS = 9

ICOR = 0

IBUN = 0

IMES = 0

In addition the following parameters have a more restrictive definition than given in the users manual:

$0 \leq \text{ISHUF} \leq 1$

$0 \leq \text{IPIR} \leq 1$

The user will notice that the IDP requests redundent information. For example, the parameter IT is requested as control information; and, the number of elements is also required in element descriptions. This redundancy is required in order to simplify the IDP; if these redundancies were eliminated the data management tasks would be increased. The IDP does contain an error check to assure that redundant control parameters are consistant.

You will note that the IDP requires a data item in addition to that normally required by the analysis program - the class of structure. The various structural classes are described by the interactive mode of the IDP with maximum prompting; and are defined by Table A-5 of reference (5). The class number determines the type of elements that may be used; and, the IDP logic restricts the user to the class/element relation defined by the table referenced above.

The only difference between a normal ELAS run and a viscoelastic run is the inclusion of the parameter ISUCA which, again is defined in the IDP as follows:

- EQ.0 Signals termination of the input; if ISUCA has not been previously defined then this indicates that a standard ELAS run is to be made
- LT.0 Allows multiple runs
- GT.0 Indicates Viscoelastic run
- EQ.1 Master data and following modified data
- GT.1 For additional modified data sets.

5.2.1 Interactive Mode

In the interactive mode the IDP sets up a question - answer dialogue with the user. The IDP defines a data set to be input and then accepts the input in unformatted form directly from the terminal keyboard. The ELAS/VISCEL IDP has two level of prompting which is controlled by user request. The minimum prompting mode requests data elements by displaying the data element mneumonics; while the maximum prompting mode defines each of the data elements.

In either the interactive or the data file mode the IDP creates a formatted input file for the VISCEL/ELAS analysis program. This file which is stored on a mass storage device must be identified by means of a file name. The program thus requests the user to enter a name for the file. The IDP will then catalog the file; and, an error will result if the file already exists. The user should note that the file is cataloged as a private file and may be named using read keys as follows.

QUALIFIER*NAME/KEY1/KEY2/

where KEY1 is the write key; KEY2 is the read key. The user is cautioned to retain these keys in a secure place, if used.

5.2.2 Data File Mode

In this mode the user prepares a data file containing the responses to the IDP either off-line using a paper tape or tape cassette; or on line using the text editor. The data elements are described by Table 5.1. The purpose of this input mode is to allow the user to prepare an input file for the IDP so that the prompting produced by the IDP can be bypassed.

The IDP will query the user to determine if the data file mode is to be used. If so, the user is requested to enter the name of the file containing the

prepared file of unformatted input. The IDP will then read from this file to satisfy read requests completely by-passing the interactive prompting.

Occasionally the user may make an error in preparing the data file which will cause a read-error in the IDP, and an error exit. The information printed by the system at this time will be of little assistance in identifying the data elements which are in error. A recommended procedure at this point is to place the IDP in the prompting mode; but to cause the IDP to read the pre-created data file. This can be accomplished by responding "NO" to the question "DO YOU WANT TO ENTER DATA FROM A DATA FILE?". Then in response to the first prompt for data the data file is added by the command

```
@ADD QUALIFIER*NAME
```

The IDP now prints all prompting, but reads the data from the data file. It is then possible to identify the data elements in error by noting at which point the error exists.

5.2.3 IDP Input Requirements

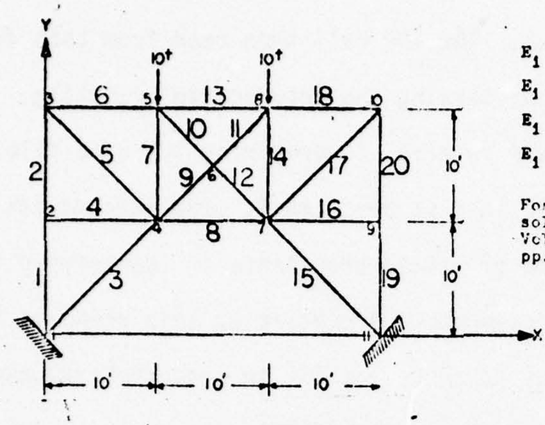
The order in which the IDP prompts the user for input differs slightly from the ELAS/VISCEL manuals, and provides default values for scratch tapes etc. In addition, the IDP does not allow the user to input parameters which would require user prepared subroutines.

5.3 Examples

The ELAS examples are taken from reference 8.

5.3.1 Planar Truss Case

The planar truss is as shown by figure 5.1



$E_i = 250{,}000\ t/ft^2$, $A_i = 0.1\ ft^2$, $i=1,\ldots,5$

$E_i = 250{,}000\ t/ft^2$, $A_i = 0.2\ ft^2$, $i=6,\ldots,10$

$E_i = 500{,}000\ t/ft^2$, $A_i = 0.1\ ft^2$, $i=11,\ldots,15$

$E_i = 500{,}000\ t/ft^2$, $A_i = 0.3\ ft^2$, $i=16,\ldots,20$

For $(AE)_i$ = constant, $i=1,\ldots,20$ case see the solution in _Hyperstatic Structures_, J.A.L.Matheson Vol.I, Academic Press, Inc., New York 1959, pp.158-162.

FIGURE 5.1 Planar Truss

Before proceeding to execute the IDP we will have to refer to the ELAS/VISCEL manuals to define certain of the control parameters. Referring to Table 5.2, which is taken from reference (5) we see that the planar truss is structural class number one; and, that there is only one element type associated with this structural class; the planar truss. Finally, referring to Table 5.3 we see that the parameters IDEG, NVERT, NWDS have the following values:

IDEG = 2 (column 4 of Table 5.3)

NVERT = 2 (column 3 of Table 5.3)

NWDS = 5 (column 5 of Table 5.3)

With this information we can write the data elements of data sets 2,3,4, and 5 as follows:

Set number	Data Elements
2	(11, 20, 2)
3	(0, 0, 0, 2, 5, 4)
4	(1, 0, 1, 0, 0, 0, 0)
5	(2, 0, 0, 0, 0)

Where we have indicated by setting NDBC = 4 that four displacement boundary conditions are to be supplied; and by ITYPE = 0 that isotropic material properties are to be used.

5.3.1.1 Interactive Mode

The interactive input mode for the creation of the formatted ELAS/VISCEL input file is as follows; where the formatted ELAS input data is to be written onto a file called PRØB01.

```
@XQT SYMPOSIUM*PREPROCESSOR.VISCEL

                    ***** TS007 *****

          INPUT DATA PREPROCESSOR FOR ELAS/VISCEL


 ENTER NAME OF OUTPUT DATA FILE
PROB01

 DO YOU WANT TO ENTER DATA FROM A DATA FILE (YES OR NO)
NO

 DO YOU WANT MINIMUM PROMPTING (YES OR NO)
NO

 UNIVAC 1100-SERIES VERSION. INPUT DATA TO BE ENTERED FROM EITHER
 THE INTERACTIVE MODE OR THE DATA FILE MODE USING FREE FORM INPUT AS
 DESCRIBED IN THE UNIVAC FORTRAN V MANUAL. IN THIS MODE THE INDIVIDUAL
 ELEMENTS OF THE INPUT DATA SET ARE SEPARATED BY COMMAS. THE DECIMAL
 POINT (.) IS REQUIRED FOR REAL NUMBERS; THE NORMAL FORTRAN SIGN CONVEN-
 SION IS FOLLOWED FOR VARIABLE NAMES UNLESS OTHERWISE NOTED.

 ENTER TITLE (72 COLUMNS OR LESS)
 PLANE TRUSS PROBLEM IN MANUAL NO 8

          -CONTROL INFORMATION-

 ENTER THE DATA SET (IN,IT,IDEG)
      IN   =TOTAL NUMBER OF NODES
      IT   =TOTAL NUMBER OF ELEMENTS
      IDEG =NUMBER OF DEGREES OF FREEDOM AT NODE POINTS
11,20,2
```

```
ENTER THE DATA SET (ITYPE,IGEM,ISTR,NVERT,NWDS,NDBC)
     ITYPE-MATERIAL INDICATOR
          .EQ.0 ISOTROPIC
          .EQ.1 ORTHOTROPIC
          .EQ.2 ANISOTROPIC
     IGEM -GEOMETRY INDICATOR
          .EQ.0 TWO-D IN X-Y PLANE
          .EQ.1 THREE-D
     ISTR -PLANE STRAIN INDICATOR
          .EQ.1 PLANE STRAIN
          .EQ.0 PLANE STRESS
     NVERT=MAX NO OF ELEMENT NODES
     NWDS =MAX NO OF INPUT ITEMS TO DESCRIBE ELEMENT
     NDBS =TOTAL NO OF DEFLECTION BOUNDARY CONDITIONS

0,0,0,2,5,4


ENTER THE DATA SET (IMAT,NTIC,IAREA,ITOR,IYY,IZZ,IMFI)
     IMAT =TOTAL NO OF MATERIALS
     NTIC =TOTAL NO OF THICKNESSES
     IAREA=TOTAL NO OF CROSS-SECTIONAL AREAS
     ITOR =TOTAL NO OF TORSIONAL CONSTANTS
     IYY  =TOTAL NO OF MOMENTS OF INERTIA ABOUT Y-AXIS
     IZZ  =TOTAL NO OF MOMENTS OF INERTIA ABOUT Z-AXIS
     IMFI =TOTAL NO OF ANGLES FIXING LOCAL Y AND Z-AXES
2,0,3,0,0,0,0


ENTER THE DATA SET (IP,IPRS,ITEMP,IGRADY,IGRADZ)
     IP    =TOTAL NO OF CONCENTRATED LOADS
     IPRS  =TOTAL NO OF PRESSURES
     ITEMP =TOTAL NO OF TEMP INCREASES
     IGRADY=TOTAL NO OF TEMP GRADIENTS ALONG LOCAL Y
     IGRADZ=TOTAL NO OF TEMP GRADIENTS ALONG LOCAL Z
2,0,0,0,0


ENTER LINK AFTER WHICH EXECUTION IS TERMINATED
     .EQ.1 INPUT
     .EQ.2 GENERATION
     .EQ.3 DEFLECTION
     .EQ.4 STRESS
4


ENTER PRINT PARAMETER
     .EQ.0 MINIMUM
     .EQ.1 INTERMEDIATE
     .EQ.2 DETAILED
1
```

```
 ENTER RELABELING PARAMETER
      .EQ.0 NO RELABEL
      .EQ.1 RELABEL
0

 ENTER COORD SELECTION INDICATOR FOR SHELLS
      .EQ.0 LOCAL X IS 1-2 LINE OF LOWEST NUMBERED ELMT
      .EQ.1 PRINCIPAL
0

 ENTER (G1,G2,G3)-DIRECTION COSINES OF ACCELERATION
0.,0.,0.

 ENTER MAGNITUDE OF ACCELERATION VECTOR TIMES UNIT MASS
0.

               -MATERIAL PROPERTIES-

 ENTER  2 DATA SETS (E,G,ALPHA)
      E     =MODULUS OF ELASTICITY
      G     =SHEAR MODULUS
      ALPHA=COEF OF THERMAL EXPANSION
 MATERIAL NO  1
250000.,0.,0.
 MATERIAL NO  2
500000.,0.,0.

              -CROSS SECTIONAL AREAS-

 ENTER  3 DATA SETS (I,AREA)
      I    =AREA SET I.D.
      AREA=CROSS-SECTIONAL AREA
1,.1
2,.2
3,.3
THE INTERPRETATION OF MEANINGLESS INPUT WAS ATTEMPTED.
THE FOLLOWING RECORD IS ERRONEOUS OR DOES NOT CORRESPOND TO FORMAT SPECI
FICATIONS:
F,.3

  I/O  CALLED  AT  SEQUENCE  NUMBER 000133  OF  TS010
```

Notice that the system has made an error in interpreting the input data. Rather than terminating, the session will be continued; and, the text editor will be utilized to modify the formatted data file PRØB01.

-NODE POINT GEOMETRY-

```
 IS THIS A PLANAR PROBLEM (YES OR NO)
YES

 ENTER 11 DATA SETS (X,Y)
 NODE  1
0.,0.
 NODE  2
0.,10.
 NODE  3
0.,20.
 NODE  4
10.,0-10.
 NODE  5
10.,20.
 NODE  6
15.,15.
 NODE  7
20.,10.
 NODE  8
20.,20.
 NODE  9
30.,10.
 NODE 10
30.,20.
 NODE 11
30.,0.
```

-DEFLECTION BOUNDARY CONDITIONS-

```
 ENTER   4SETS (NODE,IDOF,NODE-P,IDOF-P,VALUE)
      NODE  =NODE NO OF INDEPENDENT D.O.F.
      IDOF  =D.O.F. NO.
      NODE-P=NODE NO OF RELATED D.O.F.
      IDOF-P=D.O.F. NO.
      VALUE =COEFFICIENT
1,1,1,1,0.
1,2,1,2,0.
11,1,11,1,0.
11,2,11,2,0.
```

-ELEMENT DESRIPTIONS-

```
THE TYPES OF FINITE ELEMENTS WHICH MAY BE USED TO DESCRIBE ANY
STRUCTURAL SYSTEM IS DEPENDENT ON THE CLASS OF STRUCTURAL SYSTEM.

THE CLASSES OF STRUCTURAL SYSTEMS ALLOWED IN THIS PROGRAM ARE AS
FOLLOWS

CLASS        DESRIPTION
   1    PLANAR TRUSS
   2    SPACE TRUSS
   3    PLANAR FRAME
   4    SPACE FRAME
   5    GRIDWORK FRAME
   6    PLANE STRESS
   7    PLANE STRAIN
   8    PLATE BENDING
   9    GENERAL SOLID
  10    GENERAL SHELL; BENDING, MEMBRANE
  11    GENERAL SHELL, MEMBRANE
  12    SOLID OF REVOLUTION
  13    SHELL OF REVOLUTION, MEMBRANE
  14    SHELL OF REVOLUTION; BENDING, MEMBRANE

ENTER CLASS OF STRUCTURE
1

YOU HAVE SPECIFIED STRUCTURAL CLASS  1
THE COMPATABLE ELEMENTS FOR THIS STRUCTURAL CLASS ARE SPECIFIED BY
TABLE III-2  OF THE ELAS MANUAL; AND, YOU ARE RESTRICTED TO THESE
ELEMENTS BY THE PREPROCESSOR.

ENTER NUMBER OF TYPE  1 ELEMENTS
20

ENTER  20 DATA SETS OF THE FOLLOWING FORM
(N1,N2,NMAT,IAREA,IPRESS,ITEMP)
     N1     =NODE NUMBER  OF FIRST VERTEX
     N2     =NODE NUMBER  OF SECOND VERTEX
     MAT    =MATERIAL TYPE NUMBER
     NAREA  =CROSS-SECTIONAL AREA TYPE NUMBER
     IPRESS=PRESSUE TYPE NUMBER
     ITEMP  =UNIFORM TEMP INCREASE TYPE NUMBER
 ELMT  1
1,2,1,1,0,0
?@ELMT  2
2,3,1,1,0,0
 ELMT  3
1,4,1,1,0,0
```

```
 ELMT  4
2,4,1,1,0,0
 ELMT  5
3,4,1,1,0,0
 ELMT  6
3,5,1,2,0,0
 ELMT  7
4,5,1,2,0,0
 ELMT  8
4,7,1,2,0,0
 ELMT  9
4,6,1,2,0,0
 ELMT 10
2,6,1,2,0,0
 ELMT 11
6,8,2,1,0,0
 ELMT 12
6,7,2,1,0,0
 ELMT 13
5,8,2,1,0,0
 ELMT 14
7,8,2,1,0,0
 ELMT 15
7,11,2,1,0,0
 ELMT 16
7,9,2,3,0,0
 ELMT 17
7,10,2,3,0,0
 ELMT 18
8,10,2,3,0,0
 ELMT 19
9,11,2,3,0,0
 ELMT 20
9,10,2,3,0,0


          -CONCENTRATED NODE FORCES AND MOMENTS-

 ENTER  2 DATA SETS OF THE FORM (NODE,IDOF,VALUE) WHERE:
      NODE=NODE LABEL NO.
      IDOF=DEGREE OF FREEDOM CODE
           .EQ.1 FORCE IN X-DIR
           .EQ.2 FORCE IN Y-DIR
           .EQ.3 FORCE IN Z-DIR
           .EQ.4 MOMENT ABOUT X-AXIS
           .EQ.5 MOMENT ABOUT Y-AXIS
           .EQ.6 MOMENT ABOUT Z-AXIS
      VALUE=MAGNITUDE OF FORCE COMPONENT
5,2,-10.
8,2,-10.


 ENTER INCREMENTAL PARAMETER ISUCA
      .EQ.0 STANDARD LINEAR ELASTIC (ELAS) SOLUTION
      .LT.1 MULTIPLE RUN
      .GE.1 VALUE OF M FOR VISCOELASTIC SOLUTION
0
```

```
DO YOU WANT A SUMMARY OF THE INPUT DATA (YES OR NO)
YES

          -SUMMARY OF ELAS/VISCEL INPUT DATA-

PLANE TRUSS PROBLEM IN MANUAL NO 8

     -CONTROL INFORMATION-

NUMBER OF NODES......  11
NUMBER OF ELMTS......  20
D.O.F PER NODE.......   2
MATERIAL INDICATOR...   0
GEOMETRY INDICATOR...   0
TWO-D THEORY INDIC...   0
MAX. NO VERTICES.....   2
MAX. NO WORDS/ELMT...   5
NO OF DBC UNITS......   4
EXECUTION OPTION.....   4
PRINTOUT INDICATOR...   1
RELABEL INDICATOR....   0
COORD GEN INDICATOR..   0
DBC GEN INDICATOR....   0
ELMT GEN INDICATOR...   0
LOCAL COOR INDICATOR.   0
G1...................      .0000
G2...................      .0000
G3...................      .0000
ACEL.................      .0000
NO. OF CONCENTRATED LOADS..  2
NO. OF PRESSURES...........  0
NO. OF MATERIALS...........  2
NO. OF THICKNESSES.........  0
NO. OF TEMP. INCREASES.....  0
NO. OF Y-GRADIENTS.........  0
NO. OF Z-GRADIENTS.........  0
NO. OF CROSS SECT. AREAS...  3
NO. OF TORSIONAL CONSTANTS.  0
NO. OF Y-MOM. OF INERTIA...  0
NO. OF Z-MOM. OF INERTIA...  0
NO. OF LOCAL COORD SYSTEMS.  0

     -MATERIAL PROPERTIES-

MATL      E            G           ALPHA
   1   .25000+06    .00000        .00000
   2   .50000+06    .00000        .00000
```

-CROSS SECTIONAL AREAS-

TYPE	VALUE
1	.10000+00
2	.20000+00
0	.00000

-MESH POINT DEFINITIONS-

NODE	X	Y	Z
1	.0000	.0000	.0000
2	.0000	.1000+02	.0000
3	.0000	.2000+02	.0000
4	.1000+02	.1000+02	.0000
5	.1000+02	.2000+02	.0000
6	.1500+02	.1500+02	.0000
7	.2000+02	.1000+02	.0000
8	.2000+02	.2000+02	.0000
9	.3000+02	.1000+02	.0000
10	.3000+02	.2000+02	.0000
11	.3000+02	.0000	.0000

-DEFLECTION CONSTRAINTS-

DEPENDENT NODE	DEPENDENT DOF	INDEPENDENT NODE	INDEPENDENT DOF	VALUE
1	1	1	1	.00000
1	2	1	2	.00000
11	1	11	1	.00000
11	2	11	2	.00000

-ELEMENT DESCRIPTIONS-

ELMT NO	ELMT TYPE	MATL TYPE	NODE 1	NODE 2	ANGL TYPE	AREA TYPE	JMMX TYPE	JMMY TYPE	JMMZ TYPE	PRES TYPE	TEMP TYPE	JSDY TYPE	JSDZ TYPE
1	1	1	1	2	0	1	0	0	0	0	0	0	0
2	1	1	2	3	0	1	0	0	0	0	0	0	0
3	1	1	1	4	0	1	0	0	0	0	0	0	0
4	1	1	2	4	0	1	0	0	0	0	0	0	0
5	1	1	3	4	0	1	0	0	0	0	0	0	0
6	1	1	3	5	0	2	0	0	0	0	0	0	0
7	1	1	4	5	0	2	0	0	0	0	0	0	0
8	1	1	4	7	0	2	0	0	0	0	0	0	0
9	1	1	4	6	0	2	0	0	0	0	0	0	0
10	1	1	2	6	0	2	0	0	0	0	0	0	0

11	1	2	6	8	0	1	0	0	0	0	0	0	0
12	1	2	6	7	0	1	0	0	0	0	0	0	0
13	1	2	5	8	0	1	0	0	0	0	0	0	0
14	1	2	7	8	0	1	0	0	0	0	0	0	0
15	1	2	7	11	0	1	0	0	0	0	0	0	0
16	1	2	7	9	0	3	0	0	0	0	0	0	0
17	1	2	7	10	0	3	0	0	0	0	0	0	0
18	1	2	8	10	0	3	0	0	0	0	0	0	0
19	1	2	9	11	0	3	0	0	0	0	0	0	0
20	1	2	9	10	0	3	0	0	0	0	0	0	0

```
   -CONCENTRATED NODAL LOAD-

NODE  DOF     VALUE

  5    2   -.1000+02

END OF INPUT FOR LINEAR ELASTIC PROBLEM

IS THERE ANOTHER DATA CASE (YES OR NO)
NO


NORMAL EXIT.  EXECUTION TIME:        2268 MILLISECONDS.
DATA IGNORED - IN CONTROL MODE
```

The output file PRØB01. will now be edited to change the area information that was misinterpreted by the program. We also noted during the summary of input data that the connectivity information for member 10 is incorrect. The element is presently connected between nodes 2 and 6; this will be corrected to be between nodes 5 and 6. The editor session to correct PRØB01. is as follows.

```
@ED PROB01
ED 28D 04/29-09:50-(00):F
EDIT
*G 4
 1 .100+00 2 .200     0 .000
*C /0 .000/3 .300/
 1 .100+00 2 .200     3 .300
*T
*P 50

 PLANE TRUSS PROBLEM IN MANUAL NO 3
  11  20200025   4   2   0 2 0 0 0 0 3 0 0 0 0410000020   .0   .0   .0
 .000
 1 .250+06 .000     .000    2 .500+06 .000     .000
 1 .100+00 2 .200     3 .300
   1     .0000        .0000        .0000
   2     .0000        .1000+02     .0000
   3     .0000        .2000+02     .0000
   4     .1000+02     .1000+02     .0000
   5     .1000+02     .2000+02     .0000
   6     .1500+02     .1500+02     .0000
   7     .2000+02     .1000+02     .0000
   8     .2000+02     .2000+02     .0000
   9     .3000+02     .1000+02     .0000
  10     .3000+02     .2000+02     .0000
  11     .3000+02     .0000        .0000
   11    11    .00    12    12    .00   111   111    .00   112   112    .00
   -1 101 100    0   1   2   0   0   0   0   0
   -2 101 100    0   2   3   0   0   0   0   0
   -3 101 100    0   1   4   0   0   0   0   0
   -4 101 100    0   2   4   0   0   0   0   0
   -5 101 100    0   3   4   0   0   0   0   0
   -6 101 200    0   3   5   0   0   0   0   0
   -7 101 200    0   4   5   0   0   0   0   0
   -8 101 200    0   4   7   0   0   0   0   0
   -9 101 200    0   4   6   0   0   0   0   0
  -10 101 200    0   2   6   0   0   0   0   0
  -11 102 100    0   6   8   0   0   0   0   0
  -12 102 100    0   6   7   0   0   0   0   0
  -13 102 100    0   5   8   0   0   0   0   0
  -14 102 100    0   7   8   0   0   0   0   0
  -15 102 100    0   7  11   0   0   0   0   0
  -16 102 300    0   7   9   0   0   0   0   0
  -17 102 300    0   7  10   0   0   0   0   0
  -18 102 300    0   8  10   0   0   0   0   0
  -19 102 300    0   9  11   0   0   0   0   0
  -20 102 300    0   9  10   0   0   0   0   0
    52   -.1000+02   82   -.1000+02

    0END
EOF AT LINE 38
*T
*L -10
 -10 101 200    0   2   6   0   0   0   0   0
*C /2   6/5   6/
 -10 101 200    0   5   6   0   0   0   0   0
*E
END EDIT 38 LINES OUTPUT
```

5.3.1.2 Data File Mode

The input data for the VISCEL/ELAS IDP is created by using the text editor. First a file must be created using the system commands

```
@CAT,UP  ELASPROBS
@FREE  ELASPROBS.
```

An element called TRUSS will now be created using the UoM text editor as follows:

```
@ED  TRUSS
INPUT
```

(The input data has not been shown)

Note that the element TRUSS was created in the workspace and copied to the file ELASPROBS.TRUSS by the command

@COPY, S TRUSS, ELASPROBS.

The IDP is now executed in the data file mode as follows, where, again we assume that PRØB01 contains the formatted output file.

```
@XQT SYMPOSIUM*PREPROCESSOR.VISCEL

                              ***** TS007 *****

                    INPUT DATA PREPROCESSOR FOR ELAS/VISCEL

 ENTER NAME OF OUTPUT DATA FILE
PROB01.

 DO YOU WANT TO ENTER DATA FROM A DATA FILE (YES OR NO)
YES

 ENTER NAME OF INPUT  DATA FILE
ELASPROBS.TRUSS

            -SUMMARY OF ELAS/VISCEL INPUT DATA-

 PLANAR TRUSS CASE

     -CONTROL INFORMATION-

 NUMBER OF NODES...... 11
 NUMBER OF ELMTS...... 20
 D.O.F PER NODE.......  2
 MATERIAL INDICATOR...  0
 GEOMETRY INDICATOR...  0
 TWO-D THEORY INDIC...  0
 MAX. NO VERTICES.....  2
 MAX. NO WORDS/ELMT...  5
 NO OF DBC UNITS......  4
```

```
EXECUTION OPTION.....  4
PRINTOUT INDICATOR...  2
RELABEL INDICATOR....  0
COORD GEN INDICATOR..  0
DBC GEN INDICATOR....  0
ELMT GEN INDICATOR...  0
LOCAL COOR INDICATOR.  0
G1..................     .0000
G2..................     .0000
G3..................     .0000
ACEL................     .0000
NO. OF CONCENTRATED LOADS..  2
NO. OF PRESSURES...........  0
NO. OF MATERIALS...........  2
NO. OF THICKNESSES.........  0
NO. OF TEMP. INCREASES.....  0
NO. OF Y-GRADIENTS.........  0
NO. OF Z-GRADIENTS.........  0
NO. OF CROSS SECT. AREAS...  3
NO. OF TORSIONAL CONSTANTS.  0
NO. OF Y-MOM. OF INERTIA...  0
NO. OF Z-MOM. OF INERTIA...  0
NO. OF LOCAL COORD SYSTEMS.  0
```

-MATERIAL PROPERTIES-

MATL	E	G	ALPHA
1	.25000+06	.00000	.00000
2	.50000+06	.00000	.00000

-CROSS SECTIONAL AREAS-

TYPE	VALUE
1	.10000+00
2	.20000+00
3	.30000+00

-MESH POINT DEFINITIONS-

NODE	X	Y	Z
1	.0000	.0000	.0000
2	.0000	.1000+02	.0000
3	.0000	.2000+02	.0000
4	.1000+02	.1000+02	.0000
5	.1000+02	.2000+02	.0000
6	.1500+02	.1500+02	.0000
7	.2000+02	.1000+02	.0000
8	.2000+02	.2000+02	.0000
9	.3000+02	.1000+02	.0000
10	.3000+02	.2000+02	.0000
11	.3000+02	.0000	.0000

-DEFLECTION CONSTRAINTS-

DEPENDENT NODE	DEPENDENT DOF	INDEPENDENT NODE	INDEPENDENT DOF	VALUE
1	1	1	1	.00000
1	2	1	2	.00000
11	1	11	1	.00000
11	2	11	2	.00000

-ELEMENT DESCRIPTIONS-

ELMT NO	ELMT TYPE	MATL TYPE	NODE 1	NODE 2	ANGL TYPE	AREA TYPE	JMMX TYPE	JMMY TYPE	JMMZ TYPE	PRES TYPE	TEMP TYPE	JSDY TYPE	JSDZ TYPE
1	1	1	1	2	0	1	0	0	0	0	0	0	0
2	1	1	2	3	0	1	0	0	0	0	0	0	0
3	1	1	1	4	0	1	0	0	0	0	0	0	0
4	1	1	2	4	0	1	0	0	0	0	0	0	0
5	1	1	3	4	0	1	0	0	0	0	0	0	0
6	1	1	3	5	0	2	0	0	0	0	0	0	0
7	1	1	4	5	0	2	0	0	0	0	0	0	0
8	1	1	4	7	0	2	0	0	0	0	0	0	0
9	1	1	4	6	0	2	0	0	0	0	0	0	0
10	1	1	5	6	0	2	0	0	0	0	0	0	0
11	1	2	6	8	0	1	0	0	0	0	0	0	0
12	1	2	6	7	0	1	0	0	0	0	0	0	0
13	1	2	5	8	0	1	0	0	0	0	0	0	0
14	1	2	7	8	0	1	0	0	0	0	0	0	0
15	1	2	7	11	0	1	0	0	0	0	0	0	0
16	1	2	7	9	0	3	0	0	0	0	0	0	0
17	1	2	7	10	0	3	0	0	0	0	0	0	0
18	1	2	8	10	0	3	0	0	0	0	0	0	0
19	1	2	9	11	0	3	0	0	0	0	0	0	0
20	1	2	9	10	0	3	0	0	0	0	0	0	0

-CONCENTRATED NODAL LOAD-

NODE	DOF	VALUE
5	2	-.1000+02

END OF INPUT FOR LINEAR ELASTIC PROBLEM

NORMAL EXIT. EXECUTION TIME: 2771 MILLISECONDS.

5.3.1.3 Analysis Problem Execution

Using one of the two modes in the IDP we have created a file PRØB01. which contains the input data for the VISCEL/ELAS analysis program. The analysis program can be executed in the demand mode, but since the output may be more than we care to view on the terminal we will redirect the output by the command @SUSPEND and resume terminal printing by @RESUME. These two commands are transparent, and serve the function of BRKPT'ing. We also note that since the input is in file PRØB01 we must append it to the input stream by an @ADD-card.

```
@SUSPEND
@XQT SYMPOSIUM*PROGRAM.VISCEL
@ADD PROB01.
@RESUME
EXAMINE, PRINT, DELETE, OR HOLD? E
EDIT
```

The results will be scanned to determine whether they agree with published results; the interative session is as follows.

```
*L NODAL D
 NODAL DEFLECTIONS
*P 10
 NODAL DEFLECTIONS

 NODE X-DISPLMT Y-DISPLMT Z-DISPLMT X-ROTATN. Y-ROTATN. Z-ROTATN.

    1  .0000       .0000     .0000      .0000      .0000      .0000
    2 -.6366-03 -.1566-02   .0000      .0000      .0000      .0000
    3 -.1954-02 -.3133-02   .0000      .0000      .0000      .0000
    4 -.6366-03 -.6247-02   .0000      .0000      .0000      .0000
    5 -.2737-02 -.7706-02   .0000      .0000      .0000      .0000
    6 -.1721-02 -.5926-02   .0000      .0000      .0000      .0000
*E
```

The results agree, the contents of the output file are thus printed at RMENGR

```
EXAMINE, PRINT, DELETE, OR HOLD? P
WHERE? RMENGR
SENT BY: SHAFET : RMENGR
```

5.3.1.4 Printed Results

The output file for the example problem is as follows:

```
FLAS.PL1 PROG/15.07.71/

PLANE TRUSS PROBLEM IN MANUAL NO 8

PROBLEM TYPE:       EQUILIBRIUM
TOTAL NUMBER OF NODES         11
TOTAL NUMBER OF ELEMENTS      20
DEGREES OF FREEDOM PER NODE    2
ITYPE VALUE                    0
IGTM VALUE                     0
ISTR VALUE                     0
NO.OF VERTICES PER ELEMENT     2
WORDS PER ELEMENT DESCRPTN.    5
NO.OF DPC INPUT UNITS          4
NO.OF C.LOAD INPUT UNITS       2
NO.OF PRESSURE TYPES           0
NO.OF MATERIAL TYPES           2
NO.OF THICKNESS TYPES          0
NO.OF TEMP.CHANGE TYPES        0
NO.OF Y-TEMP.GRAD.TYPES        0
NO.OF Z-TEMP.GRAD.TYPES        0
NO.OF AREA TYPES               3
NO.OF TORSION CONS.TYPES       0
NO.OF Y-MOMNT.OF IN.TYPES      0
NO.OF Z-MOMNT.OF IN.TYPES      0
NO.OF ANGLE FI TYPES           0
INY VALUE                      4
INP VALUE                      1
ISHUF VALUE                    0
ICOR VALUE                     0
IFUN VALUE                     0
IMTS VALUE                     0
IFTR VALUE                     0
SCRATCH TAPE NUMBER            9
PLOT INPUT TAPE NUMBER         0
ACCELERATN*UNIT MASS .0000
ACCEL.DIR.COS.   .000   .000   .000
```

NODAL DEFLECTIONS

NODE	X-DISPLMT	Y-DISPLMT	Z-DISPLMT	X-ROTATN.	Y-ROTATN.	Z-ROTATN.
1	.0000	.0000	.0000	.0000	.0000	.0000
2	-.5360-03	-.1766-02	.0000	.0000	.0000	.0000
3	-.1954-02	-.3133-02	.0000	.0000	.0000	.0000
4	-.5360-03	-.5247-02	.0000	.0000	.0000	.0000
5	-.2737-02	-.7706-02	.0000	.0000	.0000	.0000
6	-.1721-02	-.5926-02	.0000	.0000	.0000	.0000
7	-.5299-03	-.3972-02	.0000	.0000	.0000	.0000
8	-.2980-02	-.5431-02	.0000	.0000	.0000	.0000
9	-.5299-03	-.2611-03	.0000	.0000	.0000	.0000
10	-.3241-02	-.5721-03	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000

```
STRESS AND MOMENT RESULTANTS AT THE NODES OF ONE DIMENSIONAL ELEMENTS.
QUANTITIES ARE IN LOCAL COORDINATE SYSTEMS AT THE ENDS OF ELEMENTS
ELT NOD TP          N-X          Q-Y          Q-Z          M-X          M-Y          M-Z
  1DIR COS XI   .000 1.000   .000ET-1.000   .000   .000ZT   .000   .000 1.000
  1   1  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  1   2  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  2DIR COS XI   .000 1.000   .000ET-1.000   .000   .000ZT   .000   .000 1.000
  2   2  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  2   3  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  3DIR COS XI   .707   .707   .000ET  -.707   .707   .000ZT   .000   .000 1.000
  3   1  1   -.9604+01   .0000        .0000        .0000        .0000        .0000
  3   4  1   -.9604+01   .0000        .0000        .0000        .0000        .0000
  4DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
  4   2  1   -.1490-07   .0000        .0000        .0000        .0000        .0000
  4   4  1   -.1490-07   .0000        .0000        .0000        .0000        .0000
  5DIR COS XI   .707  -.707   .000ET   .707   .707   .000ZT   .000   .000 1.000
  5   3  1    .5538+01   .0000        .0000        .0000        .0000        .0000
  5   4  1    .5538+01   .0000        .0000        .0000        .0000        .0000
  6DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
  6   3  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  6   5  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
  7DIR COS XI   .000 1.000   .000ET-1.000   .000   .000ZT   .000   .000 1.000
  7   4  1   -.7299+01   .0000        .0000        .0000        .0000        .0000
  7   5  1   -.7299+01   .0000        .0000        .0000        .0000        .0000
  8DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
  8   4  1    .5333+00   .0000        .0000        .0000        .0000        .0000
  8   7  1    .5333+00   .0000        .0000        .0000        .0000        .0000
  9DIR COS XI   .707   .707   .000ET  -.707   .707   .000ZT   .000   .000 1.000
  9   4  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
  9   6  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 10DIR COS XI   .707  -.707   .000ET   .707   .707   .000ZT   .000   .000 1.000
 10   5  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 10   6  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 11DIR COS XI   .707   .707   .000ET  -.707   .707   .000ZT   .000   .000 1.000
 11   6  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 11   8  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 12DIR COS XI   .707  -.707   .000ET   .707   .707   .000ZT   .000   .000 1.000
 12   6  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 12   7  1   -.3820+01   .0000        .0000        .0000        .0000        .0000
 13DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
 13   5  1   -.1215+01   .0000        .0000        .0000        .0000        .0000
 13   8  1   -.1215+01   .0000        .0000        .0000        .0000        .0000
 14DIR COS XI   .000 1.000   .000ET-1.000   .000   .000ZT   .000   .000 1.000
 14   7  1   -.7299+01   .0000        .0000        .0000        .0000        .0000
 14   8  1   -.7299+01   .0000        .0000        .0000        .0000        .0000
 15DIR COS XI   .707  -.707   .000ET   .707   .707   .000ZT   .000   .000 1.000
 15   7  1   -.9604+01   .0000        .0000        .0000        .0000        .0000
 15  11  1   -.9604+01   .0000        .0000        .0000        .0000        .0000
 16DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
 16   7  1   -.1192-06   .0000        .0000        .0000        .0000        .0000
 16   9  1   -.1192-06   .0000        .0000        .0000        .0000        .0000
 17DIR COS XI   .707   .707   .000ET  -.707   .707   .000ZT   .000   .000 1.000
 17   7  1    .5538+01   .0000        .0000        .0000        .0000        .0000
 17  10  1    .5538+01   .0000        .0000        .0000        .0000        .0000
 18DIR COS XI 1.000   .000   .000ET   .000 1.000   .000ZT   .000   .000 1.000
 18   8  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
 18  10  1   -.3916+01   .0000        .0000        .0000        .0000        .0000
```

```
10DIR COS XT  .000-1.000  .0000ET 1.000  .000  .0000ZT  .000  .000 1.000
10    9  1  -.3916+01  .0000        .0000         .0000        .0000        .0000
10   11  1  -.3916+01  .0000        .0000         .0000        .0000        .0000
20DIR COS XT  .000 1.000  .0000ET-1.000  .000  .0000ZT  .000  .000 1.000
20    9  1  -.3916+01  .0000        .0000         .0000        .0000        .0000
20   10  1  -.3916+01  .0000        .0000         .0000        .0000        .0000
STRESS LINK TOOK     .40  SECONDS.
```

Table 5.1 - VISCEL/ELAS Preprocessor
Input Data Elements

Data Item

1. TITLE

2. (IN,IT,IDEG)

3.* (ITYPE,IGEM,ISTR,NVERT,NWDS,NDBC)

4.* (IMAT,NTIC,IAREA,ITØR,IYY,IZZ,IMFI)

5. (IP,IPRS,ITEMP,IGRADY,IGRADZ)

6. LINK - link after which execution is terminated

7. IPRINT - print parameter

8. ILABEL - relabelling parameter

9. ISHELL - coordinate selection indicator for shells

10. (G1,G2,G3)

11. ACCELERATION

12. Enter IMAT sets according to value of ITYPE

   . EQ. 0 (E, G, α)

   . EQ. 1 $(D_{11}, D_{12}, D_{14}, D_{22}, D_{24}, D_{44}, D_{55}, D_{56}, D_{66}, \alpha_1, \alpha_2)$

   . EQ. 2 $(D_{11}, D_{12}, D_{13}, D_{14}, D_{15}, D_{16}, D_{22}, D_{23}, D_{24}, D_{25}, D_{26}$

   $D_{33}, D_{34}, D_{35}, D_{36}, D_{44}, D_{45}, D_{46}, D_{55}, D_{56}, D_{66}, \alpha_1,$

   $\alpha_2, \alpha_3)$

13. IF(IPRS.EQ.0) enter no data, otherwise enter IPRS pairs:

   (ISID, PRESS)

   where ISID is the set identification number

14. IF(NTIC.EQ.0) enter no data; otherwise enter NTIC pairs

   (ISID,THICKNESS)

TABLE 5-1 (continued)

15. IF(ISDT.EQ.0) enter no data; otherwise enter ISDT pairs

    (ISID, TEMPERATURE)

16. IF(ISDY.EQ.0) enter no data; otherwise enter ISDY pairs

    (ISID,Y-TEMP GRADIENT)

17. IF (ISDZ.EQ.0) enter no data; otherwise enter ISDZ pairs

    (ISID, Z-TEMP GRADIENT)

18. IF(IARE.EQ.0) enter no data; otherwise enter IARE pairs

    (ISID,AREA)

19. IF(IMMX.EQ.0) enter no data; otherwise enter IMMX pairs

    (ISID, TORSIONAL CONSTANT)

20. IF(IMMY.EQ.0) enter no data; otherwise enter IMMY pairs

    (ISID, Y-MOMENT OF INERTIA)

21. IF(IMMZ.EQ.0) enter no data; otherwise enter IMMZ pairs

    (ISID,Z-MOMENT OF INERTIA)

22. IF(IMFI.EQ.0) enter no data; otherwise enter IMFI pairs

    (ISID,PHI)

23. ANS (YES OR NO) - IS THIS A PLANAR PROBLEM?

    Enter IN data sets

    . EQ.YES (X,Y)

    . EQ.NO (X,Y,Z)

24. If (IBUN.EQ.0) enter no data; otherwise enter IBUN sets (NODE,IDOF, NODE', IDOF', VALUE)

25. ICLASS - class of structure

TABLE 5-1 (continued)

25.A.1 .EQ.1; enter NELM - number of type 1 elements

enter NELM data sets

(N1,N2,NMAT,IAREA,IPRESS,ITEMP)

25.B.1 .EQ.2; same as 26.A

25.C.1 ..EQ.3; enter NELM - number of type 2 elements

25.C.2 ; enter NELM data sets

(N1,N2,NMAT,IAREA,IZ,IPRESS,ITEMP,IGRADY)

25.D.1 .EQ.4; enter NELM - number of type 4 elements

; enter NELM data sets

(N1,N2,NMAT,IAREA,IY,IZ,ITØR,IANGLE,IPRESS,ITEMP,IGRADY,IGRADZ)

25.E.1 .EQ.5; enter NELM - number of type 3 elements

; enter NELM data sets

(N1,N2,NMAT,IY,ITØR,IPRESS,IGRADZ)

25.F.1 .EQ.6; enter NELM1 number of type 5 elements

25.F.2 ; enter NELM1 data sets

(N1,N2,N3,NMAT,ITKN,IPRESS,ITEMP,IGRADZ)

25.F.3 IF(NELM1.GE IT) enter no data; otherwise enter NELM2 - number of type 6 elements

25.F.4 ; enter NELM2 data sets

(N1,N2,N3,N4,NMAT,ITKN,IPRESS,ITEMP,IGRADZ)

25.G.1 .EQ.7; same as 27.F

25.H.1 .EQ.8; enter NELMT1 - number of type 7 elements

25.H.2 ; enter NELMT1 data sets

TABLE 5-1 (continued)

(N1,N2,N3,NMAT,ITKN,IPRESS,IGRADZ)

25.H.3 IF(NELMT1.GE.IT) enter no data; otherwise enter NELMT2 - number of type 8 elements

25.H.4 ; enter NELMT2 data sets

(N1,N2,N3,N4,NMAT,ITKN,IPRESS,IGRADZ)

25.I.1 .EQ.9; enter NELM1 - number of type 9 elements

25.I.2 ; enter NELM1 data sets

(N1,N2,N3,N4,NMAT,IPRESS,ITEMP)

25.I.3 ; IF(NELM1.GE.IT) enter no data; otherwise enter NELM2 - number of type 10 elements

25.I.4 ; Enter NELM2 data sets

(N1,N2,N3,N4,N5,N6,N7,N8,NMAT,IPRESS,NTEMP)

25.J.1 .EQ.10; enter NELM1 - number of type 11 elements

; enter NELM1 data sets

25.J.2 (N1,N2,N3,NMAT,ITKN,IPRESS,ITEMP,IGRADZ)

25.J.3 ; IF(NELM1.GE.IT) enter no data otherwise enter NELM2 - the number of type 12 elements

25.J.4 ; enter NELM2 data sets

(N1,N2,N3,N4,NMAT,ITKN,IPRESS,ITEMP,IGRADZ)

25.K.1 .EQ.11; enter NELM1 - number of type 13 elements

25.K.2 ; enter NELM1 data sets

(N1,N2,N3,NMAT,ITKN,IPRESS,ITEMP)

25.K.3 ; IF(NELM1.GE.IT) enter no data, otherwise enter NELM2 - the number of type 14 elements

25.K.4 ; enter NELM2 data sets

(N1,N2,N3,N4, NMAT,ITKN,IPRESS,ITEMP)

TABLE 5-1 (continued)

25.L.1 .EQ.12; enter NELM1 - number of type 15 elements

25.L.2 ; enter NELM1 data sets

(N1,N2,N3,NMAT,ITKN,IPRESS,ITEMP)

25.L.3 ; IF(NELM1.GE.IT) enter no data; otherwise enter NELM2 - the number of type 16 elements

25.L.4 ; enter NELM2 data sets

(N1,N2,N3,N4,NMAT,ITKN,IPRESS,ITEMP)

25.M.1 .EQ.13; enter NELM - the number of type 17 elements

25.M.2 ; enter NELM data sets

(N1,N2,NMAT,ITKN,IPRESS,ITEMP)

25.N.1 ; enter NELM data sets

(N1,N2,NMAT,ITKN,IPRESS,ITEMP,IGRADZ)

26. IF(IP.EQ.0) enter no data; otherwise enter IP data sets

(NODE,IDOF,VALUE)

27. ISUCA

28. IF(ISUCA.NE.0) enter 3*, 4*, followed by applicable data items 14-23 26-27. This is the method of inputting the time dependent material properties. The termination of time dependent properties is indicated by setting ISUCA = 0.

29. ANS - Response to question "DO YOU WANT A SUMMARY OF THE INPUT DATA (YES OR NO)"

30. ANS - Response to question "IS THERE ANOTHER DATA CASE (YES OR NO)"

TABLE 5.2 Types of elements available for different cases of structures (element type numbers are shown in the shaded squares)

Case number	Column number	1	2	3	4	5	6	7	8
	Case description / Element type	Line segment	Triangle	Quadrilateral	Conical segment	Tetrahedron	Hexahedron	Triangular torus	Quadrilateral torus
1	Planar truss	1							
2	Space truss	1							
3	Planar frame	2							
4	Space frame	4							
5	Gridwork frame	3							
6	Plane stress		5	6					
7	Plane strain		5	6					
8	Plate bending		7	8					
9	General solid					9	10		
10	General shell; bending, membrane		11	12					
11	General shell, membrane		13	14					
12	Solid of revolution							15	16
13	Shell of revolution, membrane				17				
14	Shell of revolution; bending, membrane				18				

TABLE 5.3 Element Properties

1	2	3	4	5	6	7	8	9	10	11
Element type number	Element geometry	Number of nodes (vertices), IIAS	Degrees of freedom per node, IDEG	Number of words for element description, I8	Case No. of structure (Table III-2) for which this element may be used	Nodal line on the first material axis direction	Nodal line or nodal plane on which the pressure may exist	Pressure direction	Orientation of overall coordinate system with respect to structure	Local coordinate system of element
1	Line segment	2	2	5	1	1-2	1-2	$	○	[illegible]
1	Line segment	2	3	5	2	1-2	1-2	$	Any	[illegible]
2	Line segment	2	3	6	3	1-2	1-2	$	○	[illegible]
3	Line segment	2	3	5	5	1-2	1-2	†	○	[illegible]
4	Line segment	2	6	8	4	1-2	1-2	$	Any	[illegible]
5	Triangle	3	2	6	6, 7	◓	1-2	*	○	[illegible]
6	Quadrilateral	4	2	7	6, 7	◔	1-2	*	○	[illegible]
7	Triangle	3	3	6	8	◔	1-2-3	**	○	[illegible]
8	Quadrilateral	4	3	7	8	◔	1-2-3-4	**	○	[illegible]
9	Tetrahedron	4	3	6	9	◔	1-2-3	**	Any	[illegible]
10	Hexahedron	8	3	10	9	○	1-2-3-4	**	Any	[illegible]
11	Triangle	3	6	6	10	1-2	1-2-3	**	Any	△
12	Quadrilateral	4	6	7	10	1-2	1-2-3-4	**	Any	△
13	Triangle	3	3	6	11	1-2	1-2-3	**	Any	△
14	Quadrilateral	4	3	7	11	1-2	1-2-3-4	**	Any	△
15	Triangular torus	3	2	6	12	◓	1-2	*	◓	[illegible]
16	Quadrilateral torus	4	2	7	12	●	1-2	*	◓	[illegible]
17	Conical segment	2	2	5	13	1-2	1-2	(*)	◓	▲
18	Conical segment	2	3	5	14	1-2	1-2	(*)	◓	▲

Legend

○ structure is in the overall (X-Y) plane

◓ the mesh is in the overall (X-Y) plane and overall Y axis is the axis of revolution

◔ first material axis is the overall X axis

* normal to nodal line 1-2 and the overall Z axis, and away from element

** normal to surface shown in column 8 and in direction of local normal

(*) local z-axis direction

$ Perpendicular to the element in the plane established by the element and the overall X axis. The direction is such that the angle between the perpendicular and the X axis is less than 90 deg

† in the direction of overall Z axis

⊡ parallel to overall axes (for element type 1, for stresses, local system as in □)

△ x axis: nodal line 1-2; z axis: normal to middle surface, which sees labels counterclockwise

▲ x axis: nodal line 1-2; y axis parallel and opposite to Z axis

□ x axis: nodal line 1-2; y axis: one of the principal axes of the cross sections

6. SATANS

6.1 Introduction

The SATANS program solves Sanders' nonlinear shell equations for shells of revolution by means of a finite-difference approximation in both spatial and temporal variables. The theoretical development for the program is described by references (9) and (10).

The governing equations are reduced to coupled sets of four linear second order partial differential equations in terms of the shell meridional coordinate and the time by expanding the surface loads and the dependent variables in terms of appropriate fourier series. The nonlinear terms are treated as pseudo loads.

The spatial and temporal derivatives are approximated by finite difference operator having orders of error of the increment squared. A modification of the Houbolt implicit backward difference scheme for time derivatives is used to insure stability of the numerical determination of the time response.

The applied loads may consist of any combination of pressure loads, thermal loads, and boundary loads and initial conditions that are symmetrical about a datum plane in the shell.

6.2 SATANS Input Data Preprocessor

The SATANS IDP operates in the demand mode and allows the user to supply unformatted input data in a program-controlled logical sequence. The IDP performs some elementary checks and writes a formatted input file for the SATANS analysis program.

The IDP operates in either of two input modes: interactive and data file modes. In the interactive mode the IDP prompts the user for data elements which are then entered from the terminal. In the data file mode the user pre-prepares

the responses to the IDP input requests and saves them on a cataloged file. The IDP will then by-pass all prompting; and, will read the unformatted input from the data file.

In either mode the IDP will print a summary of the SATANS input. This summary is actually obtained by reading the formatted SATANS input file thus providing a check on both the correctness of the data items and the file structure.

The input data items required by either mode are the same. These data items are presented by Table 6.1.

6.2.1 Interactive Mode

The IDP is executed in the interactive mode by responding "NO" to the query, "Do you want to enter data from a data file?" The IDP will then lead the user through the creation of the SATANS input file by prompting for data elements which the user is to enter from the terminal device.

The IDP will set certain parameters by default according the users specification of a static or dynamic analysis. Thus, for example the parameters that are used only for a dynamic analysis are not requested if ISORD = 0.

6.2.2 The Data File Mode

The data file mode allows the user to pre-create the responses to the IDP requests for data according to Table 6.1 and thus to completely by-pass the prompting mode. In either the data file or interactive modes, the user may request that a summary of the input data be printed at the terminal.

The new user may find it convenient to use the IDP in the full prompting interactive mode as a teaching aid. The IDP will fully describe each of the data elements, and will provide the logical branches for input data.

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6.3 Changes to Standard SATANS Input Data

The SATANS program in the form described by reference 10 utilizes a minimum number of parameters for problem description, but, involves the user in defining loads, stiffness variations and geometry by means of user provided FORTRAN subroutines. This choice certainly lightens the program developers task; but, may impose an impossible burden on the engineer who is not also a programmer.

The task of providing the necessary data generation modules is formidable, and beyond the scope of this effort. An attempt has been made to assist the user to some degree, however by defining the mode numbers to be considered in the solution (item 3 on table 6.1), and by including a subroutine for the generation of the geometrical parameters for the more common shell shapes including the sphere, cone and cylinder. The user is requested to define the shell type and the associated geometric parameters by input items 11 on Table 6.1.

The explanation of the input parameters requested by the IDP for the various shape options is given by figures 6.1, 6.2 and 6.3 for the sphere, cone and cylinder, respectively. The user is referred to the users manual, reference 10 for a description of the shell parameters for the case of a general shell of revolution.

6.4 User Prepared Subroutines

The user must provide subroutines which define the surface pressure, the thermal loads, the stiffness and the initial condition. The function of these subroutines is described below.

6.4.1 Stiffness

The stiffness parameters are calculated by the subroutine:

BDB (K, B, DB, D, DD)

The nondimensional stiffness quantities b, $db/d\xi$, d, and $dd/d\xi$ are defined in BDB for each meridional station. The correspondence between the stiffness quantities at the Kth station and the FØRTRAN variables is as follows:

$$B = (b)_K = (B)_K/(E_o h_o)$$

$$DB = (\frac{db}{d\xi})_K = (\frac{dB}{ds})_K(\frac{a}{E_o h_o})$$

$$D = (d)_K = (D)_K/(E_o h_o^3)$$

$$DD = (\frac{dd}{d\xi})_K = (\frac{dD}{ds})_K(\frac{a}{E_o h_o^3})$$

where

$$B = \int E d\zeta/(1-\nu^2)$$

$$D = \int \zeta^2 E d\zeta/(1-\nu^2)$$

6.4.2 Surface Pressure

The surface pressures for the MNMAX fourier coefficients are to be defined by the subroutine:

PLOAD (K)

The nondimensional Fourier coefficients of the meridional, circumferential and normal components of the pressure load, $p_s^{(n)}$, $p_\theta^{(n)}$, and $p^{(n)}$ respectively, are defined in PLØAD for each meridional station as a function of the Fourier index.

$$PX(M) = (p_s^{(n)})_K = (q_s^{(n)})_K\ (a/\sigma_o h_o)$$

$$PT(M) = (p_\theta^{(n)})_K = (q_\theta^{(n)})_K\ (a/\sigma_o h_o)$$

$$M = 1, 2, \ldots \text{MNMAX}$$

$$PR(M) = (p^{(n)})_K = (q^{(n)})_K\ (a/\sigma_o h_o)$$

Note that these are stored as functions of M only.

6.4.3. Thermal Load

The thermal load and moment coefficients are to be defined by the subroutines

TLOAD(K)

The nondimensional Fourier coefficients of the thermal loads $t_T^{(n)}$, $m_T^{(n)}$, $\frac{d}{d\xi}(t_T^{(n)})$ and $\frac{d}{d\xi}(m_T^{(n)})$ are defined in TLØAD(K) for each meridional station as a function of the Fourier index. The FØRTRAN variables are defined as follows:

$$TT(M) = (t_T^{(n)})_K = (\epsilon_T^{(n)})_K/(\sigma_o h_o)$$

$$DT(M) = (\frac{d}{d\xi}(t_T^{(n)}))_K = (\frac{d\epsilon_T^{(n)}}{ds})_K(a/\sigma_o h_o)$$

$$EMT(M) = (m_T^{(n)})_K = (\varkappa_T^{(n)})_K\ (a/\sigma_o h_o^3)$$

$$DMT(M) = (\frac{d}{d\xi}(m_T^{(n)}))_K = (\frac{dm_T^{(n)}}{ds})\ (a^2/\sigma_o h_o^3).$$

6.4.4 Initial Conditions

For the case of a dynamic response the initial conditions are defined by the subroutine:

INITL

$$\left.\begin{aligned} Z(I,L) = (z^{(n)})_K &= \begin{bmatrix} U^{(n)}(E_o/a\sigma_o) \\ V^{(n)}(E_o/a\sigma_o) \\ W^{(n)}(E_o/a\sigma_o) \\ M_s^{(n)}(a/\sigma_o h_o^3) \end{bmatrix}_K \\ ZD\emptyset T(I,L) = (\frac{dz^{(n)}}{dt})_K &= T_o \frac{d}{dT} \begin{bmatrix} U^{(n)}(E_o/a\sigma_o) \\ V^{(n)}(E_o/a\sigma_o) \\ W^{(n)}(E_o/a\sigma_o) \\ M_s^{(n)}(a/\sigma_o h_o^3) \end{bmatrix}_K \end{aligned}\right\} \quad \begin{aligned} &I = 1,2,3,4 \\ &L = 1,2,\ \ldots\ (KMAX+2)*(MNMAX) \end{aligned}$$

The index L runs from 1 to KMAX+2 for NN(1), and from 1+KMAX+2 to 2*(KMAX+2) for NN(2), etc. The first element for each value of n corresponds to the initial ficticious station, the next element corresponds to the first station on the shell, etc.

6.4.5 COMMON Data Blocks

The parameters required to define the variables, and the variables themselves must be made available to the various subroutines. Generally speaking these data elements are transmitted by NAMED COMMON statements. The data elements and the associated NAMED COMMON are presented by Table 6.2.

6.4.6 User Definition of Subroutines

Due to the unusual nature of this program the user must modify existing subroutines prior to execution of the SATANS analysis program. The user thus proceeds in a radically different manner to execute SATANS than is used to execute the other programs. Rather than using the normal @XQT statement first proceed by making the following system command

@ADD SYMPOSIUM*PROGRAM.SATANS

This statement will copy several elements into the workspace including the following default symbolic elements for user prepared subroutines:

```
E7 TDB(2)
      SUBROUTINE BDB(K,B,DB,D,DD)                                         C    A458
      REAL NU                                                             C    A459
      COMMON                                                              C    A460
     1/BL32/TKN,ELAST,CHAR,SIGC/BL15                                      C    A461
     2/NU,U1(10),V1(10),W1(10),V2(10),U2(10),W2(10),U3(10),V3(10),W3(10)C    A462
     3/BL17/DEL                                                           C    A463
C     STIFFNESS DATA                                                      C    A464
      RETURN                                                              C    A465
      END
```

```
FT INITL(
      SUBROUTINE INITL                                                  C   A494
      COMMON /BL101/Z0(4,200),Z2(4,200),Z3(4,200),DELSE                 C   A495
     1  /BL104/ZDOT(4,200)/BL6/Z(4,200),SOE,OSE,ALOAD                   C   A496
     1/IBL2/NN(10),MNINIT                                               C   A497
     2 /IBL1/MNMAX/IBL9/MAXM/IBL10/KMAX1,KMAX2,NCONV/IBL4/KMAX,KL       C   A498
     3/BL30/TKN,ELAST,CHAR,SIGO/BL100/CORD,TEEO                         C   A499
      RETURN                                                            C   A514
       END
```

```
54 FLOAD(1)
      SUBROUTINE FLOAD(K)                                               C   A471
      COMMON                                                            C   A472
     1/BL30/TKN,ELAST,CHAR,SIGO/IBL2/NN(10),MNINIT                      C   A473
     3/BL6/Z(4,200),SOE,OSE,ALOAD                                       C   A474
     4/IBL1/MNMAX                                                       C   A475
     5/BL3/PR(10),PX(10),PT(10)                                         C   A476
      COMMON/IBL4/KMAX,KL                                               C   A477
      COMMON/BL8/R(200),GAM(200),OMT(200)                               C   A478
     1/IBL8/LSTEP,ITR                                                   C   A479
     1/BL102/DELOAD/BL103/MASS(200)                                     C   A480
      RETURN                                                            C   A481
       END
```

```
F4 TLOAD(1)
      SUBROUTINE TLOAD(K)                                               C   A483
      REAL NU                                                           C   A484
      COMMON                                                            C   A485
     1/IBL1/MNMAX/IBL2/NN(10),MNINIT                                    C   A486
     2/BL5/TT(10),EMT(10),OT(10),OMT(10)                                C   A487
     3/BL30/TKN,ELAST,CHAR,SIGO                                         C   A488
     4/BL6/Z(4,200),SOE,OSE,ALOAD/BL15/                                 C   A489
     5NU,U1(10),V1(10),W1(10),V2(10),U2(10),W2(10),U3(10),V3(10),W3(10) C   A490
     1/IBL8/LSTEP,ITR                                                   C   A491
      RETURN                                                            C   A492
       END
```

The user may now modify any one of the symbolic elements by using the U of M text editor (as we will demonstrate in a later section).

6.4.7 SATANS Analysis Program Execution

Once the user has completely defined the desired subroutines the SATANS analysis program is executed by the command:

```
@ADD  XQTSATANS
```

followed by the addition of the input file with the command

```
@ADD  FILENAME.
```

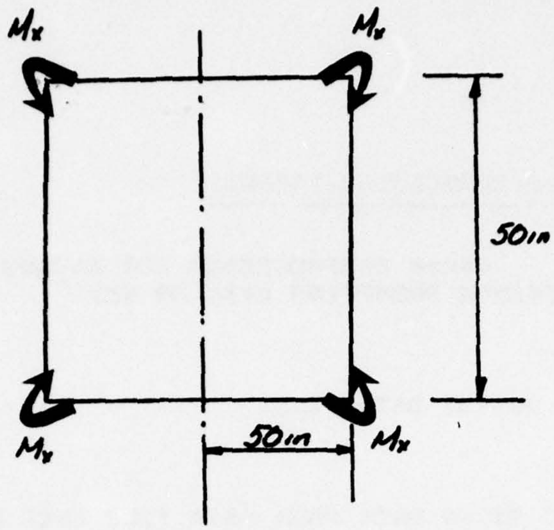
As in the other analysis systems, the user may wish to @SUSPEND and @RESUME. Let us suppose that the IDP had created the input file SATØUT then the program would be executed by the commands

```
@SUSPEND
@ADD  XQTSATANS
@ADD  SATØUT.
@RESUME
```

If you are curious about what the element XQTSATANS is doing you may list it using the text editor.

6.5 Example Problem

Consider the problem of determining the linear static response of a cylindrical shell subjected to the edge moments as shown.



$M_x^{(n)} = \cos n\theta$ (n = 0, 2, 5, 20)

$E = 30 \times 10^6$ psi

$\nu = .3$

$t = 1$ inch

All surface pressures, thermal loads and initial conditions are zero.

6.5.1 Creation of SATANS Input

We will use dimensional input, and will request dimensional output. The interactive execution of the IDP is as follows; where the data file SATIN is to be created.

```
@XQT SYMPOSIUM*PREPROCESSOR.SATANS

                    ***** PREPROCESSOR FOR SATANS *****
 DO YOU WANT MINIMUM PROMPTING (YES OR NO)
NO


 ENTER NAME OF OUTPUT DATA FILE
SATOUT


 DO YOU WANT TO ENTER DATA FROM DATA FILE (YES OR NO)
NO


 ENTER PROBLEM DESCRIPTION (.LE.72 COLS)
 CYLINDRICAL TEST CASE


          -CONTROL INFORMATION-
 ENTER THE DATA SET (ISORD,KMAX,MMMAX,MAXM)
     ISORD-ANALYSIS TYPE INDICATOR
     .EQ.0. STATIC ANALYSIS
     .GE.1. DYNAMIC ANALYSIS
     KMAX =NO OF EQUALLY SPACED MERIDNAL STATIONS
     MMMAX=NO OF FOURIER TERMS USED TO DESCRIBE B.C. AND LOADS
     MAXM =NO OF FOURIER TERMS IN SOLUTION
0,20,4,4


 ENTER  4 MODE NUMBERS
0,8,5,20


          -STATIC ANALYSIS-

 ENTER THE DATA SET (LSMAX,LCHMAX,ITRMAX,DELOAD,EPS)
     LSMAX=NO OF LOAD INTENSITIES
     LCHMAX=NO OF LOAD INCREMENT REDUCTIONS
     ITRMAX=MAX NO OF ITERATIONS
     DELOAD=LOAD INCREMENT
     EPS   =CONVERGENCE CRITERION
1,1,1,1,.,1.


          -PHYSICAL PROPERTIES-

 ARE PROPERTIES (I.E. LOADS GEOM ETC) IN DIMENSIONAL FORM
 (YES OR NO)
NO
```

```
ENTER POISSONS RATIO
.3

ENTER THE DATA SET (SIGO,ELAST,TKN,CHAR)
     SIGO =REF. STRESS
     ELAST=REF. MODULUS OF ELASTICITY
     TKN  =REF. THICKNESS
     CHAR =CHARACTERISTIC SHELL DIMENSION
1.,1.,1.,50.

IS THE OUTPUT TO BE IN NONDIMENSIONAL FORM (YES OR NO)
YES

          -BOUNDARY CONDITIONS-
IS SHELL CLOSED AT INITIAL STATION (YES OR NO)
NO
DO YOU WISH TO ENTER ONLY THE DIAGONAL ELEMENTS OF OMEGA AND LAMDA
MATRICES (YES OR NO)
NO
ENTER THE ELEMENTS OF THE OMEGA MATRIX (BY ROWS) AT THE
FIRST STATION
ROW 1
1.,0.,0.,0.
ROW 2
0.,1.,0.,0.
ROW 3
0.,0.,1.,0.
ROW 4
0.,0.,0.,0.
ENTER THE ELEMENTS OF THE LAMDA MATRIX (BY ROWS) AT THE
FIRST STATION
ROW 1
0.,0.,0.,0.
ROW 2
0.,0.,0.,0.
ROW 3
0.,0.,0.,0.
ROW 4
0.,0.,0.,1.
ENTER ELEMENTS OF THE EL-VECTOR AT THE FIRST STATION
0.,0.,0.,.02
IS SHELL CLOSED AT FINAL   STATION (YES OR NO)
NO
DO YOU WISH TO ENTER ONLY THE DIAGONAL ELEMENTS OF OMEGA AND LAMDA
MATRICES (YES OR NO)
YES
ENTER DIAGONAL ELEMENTS OF THE OMEGA MATRIX AT THE LAST  STATION
0.,1.,1.,0.
ENTER DIAGONAL ELEMENTS OF THE LAMDA MATRIX AT THE LAST  STATION
1/.0.,0.?
1.,0.,0.,1.
ENTER ELEMENTS OF THE EL-VECTOR AT THE LAST  STATION
0.,0.,0.,.02
```

```
        -OUTPUT CONTROL-
 ENTER THE DATA SET (NTHMAX,IFREQ,IPRINT,IMODE)
     NTHMAX=NO OF ANGULAR POSITIONS ( LE.6)
     IFREQ =PRINT FREQUENCY ALONG A MERIDION
     IPRINT=SOLUTION PRINT FREQUENCY
     IMODE -MODE DATA INDICATOR
     .EQ.0 SUMMED OUTPUT
     .EQ.1 MODAL OUTPUT
0,1,1,1

        -GEOMETRIC PARAMETERS-
 ENTER GEOMETRY CODE NUMBER
     .EQ.1 SPHERE
     .EQ.2 CONE
     .EQ.3 CYLINDER
     .EQ.4 GENERAL
3

 YOU HAVE SPECIFIED CYLINDRICAL GEOMETRY
 ENTER THE DATA SET (RADIUS,LENGTH)
50.,90.

 DO YOU WANT A SUMMARY OF INPUT DATA (YES OR NO)
YES

                    **** SUMMARY OF SATANS INPUT ****

 CYLINDRICAL TEST CASE

        -CONTROL INFORMATION-

     SORD  =    0
     KMAX  =   20
     NSMAX=     4
     MAXM  =    4
     LSMAX=     1
     LCMMAX=    1
     ITRMAX=    1
     IC    =    0
     TZERO =   .00000
     DELOAD=   .10000+01
     EPS   =   .10000+01
     ITAPE =    0
```

-PHYSICAL PARAMETERS-

```
NU     =   .30000+00
SIGO   =   .10000+01
ELAST  =   .10000+01
THICK  =   .10000+01
CHAR   =   .50000+02
```

-OUTPUT CONTROL PARAMETERS-

```
IMODE =     1
NDIMEN=     1
NTHMAX=     0
IFREQ =     1
IPRINT=     1
```

-MODE NUMBERS-

THE FOLLOWING MODES ARE INCLUDED IN THE ANALYSIS

```
0    2    5    20
```

-BOUNDARY CONDITIONS-

FIRST STATION

-OMEGA MATRIX-

.10000+01	.00000	.00000	.00000
.00000	.10000+01	.00000	.00000
.00000	.00000	.10000+01	.00000
.00000	.00000	.00000	.00000

-LAMDA MATRIX-

.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000
.00000	.00000	.00000	.10000+01

-EL VECTOR-

.00000	.00000	.00000	.20000-01

LAST STATION

-OMEGA MATRIX-

.00000	.00000	.00000	.00000
.00000	.10000+01	.00000	.00000
.00000	.00000	.10000+01	.00000
.00000	.00000	.00000	.00000

-LAMDA MATRIX-

.10000+01	.00000	.00000	.00000
.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000
.00000	.00000	.00000	.10000+01

-EL VECTOR-

.00000	.00000	.00000	.20000-01

```
-GEOMETRIC PARAMETERS-

CYLINDRICAL GEOMETRY
     RADIUS=    .50000+02
     LENGTH=    .50000+02


IS THERE ANOTHER CASE (YES OR NO)
NO
```

6.5.2 Listing of SATANS Input File

The SATANS input file created by the IDP is as follows:

```
@ED SATOUT.
?
ED 28D 05/06-10:10-(00):F
EDIT
*P 50

 CYLINDRICAL TEST CASE
    1    0    1    1    0    1    1    0    0   20    4    4    1    1
 1    0
   .30000+00   .10000+01   .10000+01   .10000+01   .50000+02   .00000
   .10000+01   .10000+01
    0
    0    2    5   20
    .10000000+01      .00000000         .00000000         .00000000
    .00000000         .10000000+01      .00000000         .00000000
    .00000000         .00000000         .10000000+01      .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .10000000+01
    .00000000         .00000000         .00000000         .20000000-01
    .00000000         .00000000         .00000000         .00000000
    .00000000         .10000000+01      .00000000         .00000000
    .00000000         .00000000         .10000000+01      .00000000
    .00000000         .00000000         .00000000         .00000000
    .10000000+01      .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .00000000
    .00000000         .00000000         .00000000         .10000000+01
    .00000000         .00000000         .00000000         .20000000-01
    3
   .50000+02   .50000+02
EOF AT LINE 26
*E
END EDIT 26 LINES OUTPUT
```

6.5.3 Modification of User Prepared Subroutines

The default symbolic elements for the subroutines are brought into the workspace by the command

@ADD SYMPOSIUM*PROGRAM.SATANS.

Considering the listings of the symbolic elements presented in section 6.4.6 we see that only the stiffness subroutine BDB must be changed.

Since the input is dimensional we must define dimensional quantities for B & D which are constants given by

$$B = \frac{Et}{(1 - \nu^2)}$$

$$D = \frac{Et^3}{12(1 - \nu^2)} = \frac{Bt^2}{12}$$

The subroutine BDB is thus modified as follows using the text editor.

```
@ED BDB
ED 2SD 05/06-10:15-(00):F
EDIT
*HV 72
*P 10
      SUBROUTINE BDB(K,B,DB,D,DD)
      REAL NU
      COMMON
     1/BL32/TKN,ELAST,CHAR,SIGO/BL15
     2/NU,U1(10),V1(10),W1(10),V2(10),U2(10),W2(10),U3(10),V3(10),W3(10)
     3/BL17/DEL
      RETURN
       END
EOF AT LINE 8
*U 2
      RETURN
*U
     3/BL17/DEL
*TAB # 7
```

```
*
ILLEGAL CHARACTER SEQUENCE
*
INPUT
*B=1./(1.-.3**2)
*D=B/12.
*DB=0.
*C-DD=0.

EDIT
*U 3
       B=1./(1.-.3**2)
*D 3
       D=B/12.
       DB=0.
       DD=0.
*E
END EDIT 12 LINES OUTPUT
```

6.5.4 Analysis Program Execution

The analysis program is executed using the data file SATANSIN. as input as follows:

```
@SUSPEND
@ADD XQTSATANS
@ADD SATOUT.
@RESUME
EXAMINE, PRINT, DELETE, OR HOLD? E
EDIT
*L MS,
@MAP MAP,SATANS,
*L
@XQT SATANS,
*L MS
 STA    NS       N TH      N ST       Q S       M S       M T      M ST
*P 5
 STA    NS       N TH      N ST       Q S       M S       M T      M ST
   1   .100-04  .335-04  .000     -.167-02  .100+01  .300+00  .000
   2  -.304+03  .212-04  .000     -.760-04  .236-01  .787-02  .000
   3  -.311+03  .178-04  .000     -.179-05  .556-03  .167-03  .000
   4  -.312+03  .629-05  .000     -.422-07  .131-04  .393-05  .000
*E
EXAMINE, PRINT, DELETE, OR HOLD? P
WHERE? RMENGR
SENT BY: SHAFES, : RMENGR
```

6.5.5 Analysis Program Output

The printout of the analysis program for this example problem is as follows.

```
BMAP MAP,DATANS
START=START?, PROG SIZE(I/D)=13520/23301


BXGT DATANS
 CYLINDRICAL TEST PROB


THE BOUNDARY CONDITIONS AT THE FIRST STATION ARE AS FOLLOWS
           OMEGA                                    LAMDA                          ELL
 .100+01 .000     .000     .000     .000     .000     .000     .000     .000
 .000     .100+01 .000     .000     .000     .000     .000     .000     .000
 .000     .000     .100+01 .000     .000     .000     .000     .000     .000
 .000     .000     .000     .000     .000     .000     .000     .100+01 .200-01


THE BOUNDARY CONDITIONS AT THE LAST  STATION ARE AS FOLLOWS
           OMEGA                                    LAMDA                          ELL
 .100+01 .000     .000     .000     .000     .000     .000     .000     .000
 .000     .100+01 .000     .000     .000     .000     .000     .000     .000
 .000     .000     .100+01 .000     .000     .000     .000     .000     .000
 .000     .000     .000     .000     .000     .000     .000     .100+01 .200-01
      NUMBER OF STATIONS---------------------- 20
      NUMBER OF MODES------------------------- 4
      INCREMENTAL LOAD FACTOR----------------- 1.000
      MAXIMUM NUMBER OF LOAD STEPS------------ 1
      MAXIMUM NUMBER OF ITERATIONS------------ 1
      MAXIMUM NUMBER OF LOAD FACTOR CHANGES--- 1
      CONVERGENCE CRITERION------------------- 1.000


      CHARACTERISTIC SHELL DIMENSION---     .5000+02
      REFERENCE THICKNESS--------------     .1000+01
      REFERENCE ELASTICITY-------------     .1000+01
      REFERENCE STRESS-----------------     .1000+01
      POISSON'S RATIO------------------     .3000+00


 THE DATA IS IN NONDIMENSIONAL FORM


 LOAD STEP= 1
 LOAD FACTOR=    .10000+01
 SOLUTION CONVERGED IN    1 ITERATIONS


 MODAL OUTPUT FOR N=    0 FOLLOWS


 STA   NS       NSTH      NST         QS         MS        MT        MST
   1  -.119-06 -.?07-06  .000       .17?-0?   .100+01  .300+00  .000
   2  -.1?2+0?  .?74-05  .000      -.760-04   .236-01  .707-02  .000
   3  -.176+0?  .314-05  .000      -.179-05   .??6-0?  .187-03  .000
   4  -.176+0?  .767-05  .000      -.422-07   .1?1-04  .393-05  .000
   5  -.176+0?  .47?-05  .000      -.995-0?   .3?8-06  .923-07  .000
   6  -.176+0?  .524-06  .000      -.234-10   .698-0?  .210-08  .000
```

7	-.178+03	.000	.000	-.560-12	-.436-09	-.140-09	.000
8	-.178+03	-.724-08	.000	.708-13	-.408-09	-.140-09	.000
9	-.178+03	-.724-08	.000	.354-13	.408-09	.140-09	.000
10	-.178+03	-.105-05	.000	-.354-13	.000	.000	.000
11	-.178+03	-.724-08	.000	-.177-13	.000	.000	.000
12	-.178+03	-.107-05	.000	.835-13	-.233-09	-.093-10	.000
13	-.178+03	-.724-08	.000	.124-12	.110-08	.349-09	.000
14	-.178+03	.000	.000	.354-12	.140-08	.419-09	.000
15	-.178+03	-.157-05	.000	.235-10	.582-08	.175-08	.000
16	-.178+03	.177-05	.000	.995-09	.712-06	.935-07	.000
17	-.178+03	-.105-03	.000	.422-07	.131-04	.393-05	.000
18	-.178+03	-.105-03	.000	.179-05	.556-03	.167-03	.000
19	-.178+03	.252-03	.000	.760-04	.236-01	.707-02	.000
20	-.185-04	-.000-00	.000	-.835-13	.100+01	.300+00	.000

STA	U	V	W	PHI S	PHI T	PHI
1	.337+04	.000	.187-08	-.151+02	.000	.000
2	.338+04	.000	.180+01	-.355+00	.000	.000
3	.307+04	.000	.187+01	-.877-02	.000	.000
4	.256+04	.000	.187+01	-.197-03	.000	.000
5	.215+04	.000	.187+01	-.454-05	.000	.000
6	.174+04	.000	.187+01	-.237-08	.000	.000
7	.133+04	.000	.187+01	.849-07	.000	.000
8	.919+03	.000	.187+01	.595-07	.000	.000
9	.508+03	.000	.187+01	.368-07	.000	.000
10	.984+02	.000	.187+01	.226-07	.000	.000
11	-.312+03	.000	.187+01	.287-08	.000	.000
12	-.722+03	.000	.187+01	-.193-07	.000	.000
13	-.113+04	.000	.187+01	-.368-07	.000	.000
14	-.154+04	.000	.187+01	-.311-07	.000	.000
15	-.195+04	.000	.187+01	.431-07	.000	.000
16	-.236+04	.000	.187+01	.454-05	.000	.000
17	-.277+04	.000	.187+01	.197-03	.000	.000
18	-.318+04	.000	.187+01	.837-02	.000	.000
19	-.359+04	.000	.187+01	.355+00	.000	.000
20	-.328+04	.000	-.447-07	.151+02	.000	.000

MODAL OUTPUT FOR NE 1 FOLLOWS

STA	NS	N TH	N ST	Q S	M S	M T	M ST
1	-.531-04	-.531-05	.289-01	.162-03	.100+01	.336+01	-.193+01
2	.124+01	-.547-03	.674-02	-.403-04	.923+00	.308+01	-.179+01
3	.127+01	-.547-06	.605-02	-.361-04	.847+00	.282+01	-.158+01
4	.127+01	-.131-06	.570-02	-.312-04	.781+00	.260+01	-.137+01
5	.127+01	-.327-07	.517-02	-.264-04	.724+00	.241+01	-.116+01
6	.126+01	.491-07	.447-02	-.216-04	.677+00	.226+01	-.945+00
7	.126+01	.727-07	.361-02	-.168-04	.639+00	.213+01	-.734+00
8	.126+01	.127-06	.265-02	-.120-04	.611+00	.204+01	-.524+00
9	.126+01	.127-06	.167-02	-.717-05	.592+00	.197+01	-.314+00
10	.126+01	.119-06	.547-03	-.239-05	.583+00	.194+01	-.105+00
11	.126+01	.103-06	-.547-03	.239-05	.583+00	.194+01	.105+00
12	.126+01	.119-06	-.167-02	.717-05	.592+00	.197+01	.314+00
13	.126+01	.862-07	-.265-02	.120-04	.611+00	.204+01	.524+00
14	.126+01	.139-06	-.361-02	.168-04	.639+00	.213+01	.734+00

15	.120+01	.179-06	-.446-02	.216-04	.677+00	.125+01	.845+00
16	.123+01	.137-06	-.517-02	.264-04	.724+00	.241+01	.110+01
17	.123+01	.640-07	-.576-02	.312-04	.781+00	.280+01	.177+01
18	.127+01	.697-07	-.697-02	.361-04	.847+00	.282+01	.158+01
19	.124+01	.770-07	-.658-02	.423-04	.923+00	.308+01	.179+01
20	.755-07	-.330-05	-.288-01	-.769-04	.170+01	.335+01	.193+01

STA	U	V	W	PHI S	PHI T	PHI
1	-.315+02	.737+02	-.587-01	.121+00	.917+07	-.122+01
2	-.283+02	.736+02	-.580-01	.111-02	.848+07	-.112+01
3	-.248+02	.308+02	-.645-01	-.151-02	.771+07	-.990+00
4	-.216+02	.284+01	-.587-01	-.136-02	.711+07	-.857+00
5	-.183+02	.264+02	-.574-01	-.115-02	.659+07	-.725+00
6	-.150+02	.240+02	-.540-01	-.943-03	.616+07	-.592+00
7	-.116+02	.237+02	-.524-01	-.733-03	.582+07	-.460+00
8	-.830+01	.222+02	-.507-01	-.523-03	.578+07	-.328+00
9	-.498+01	.216+02	-.495-01	-.314-03	.579+07	-.197+00
10	-.166+01	.212+02	-.491-01	-.105-03	.571+07	-.657-01
11	.166+01	.212+02	-.491-01	.105-03	.571+07	.657-01
12	.498+01	.216+02	-.495-01	.314-03	.579+07	.197+00
13	.830+01	.222+02	-.507-01	.523-03	.578+07	.328+00
14	.116+02	.237+02	-.524-01	.733-03	.582+07	.460+00
15	.150+02	.240+02	-.540-01	.943-03	.616+07	.592+00
16	.183+02	.264+02	-.574-01	.115-02	.659+07	.725+00
17	.216+02	.284+02	-.587-01	.136-02	.711+03	.857+00
18	.248+02	.308+02	-.645-01	.151-02	.771+07	.990+00
19	.283+02	.736+02	-.580-01	-.111-02	.848+07	.112+01
20	.315+02	.737+02	-.587-01	-.121+00	.917+07	.122+01

MODAL OUTPUT FOR N= 5 FOLLOWS

STA	NS	NTH	NST	QS	MS	MT	MST
1	-.558-05	-.117-04	.234-01	.109-03	.120+01	.334+01	-.136+01
2	.217+00	-.258-06	.119-01	-.137-03	.727+00	.235+01	-.121+01
3	.211+00	-.395-06	.182-01	-.114-03	.492+00	.154+01	-.100+01
4	.199+00	-.394-07	.217-01	-.929-04	.262+00	.875+00	-.820+00
5	.185+00	.241-06	.224-01	-.742-04	.102+00	.341+00	-.656+00
6	.172+00	.457-06	.210-01	-.575-04	-.228-01	-.762-01	-.510+00
7	.161+00	.537-06	.179-01	-.428-04	-.118+00	-.392+00	-.380+00
8	.152+00	.717-06	.137-01	-.295-04	-.186+00	-.619+00	-.262+00
9	.145+00	.779-06	.849-02	-.172-04	-.230+00	-.765+00	-.153+00
10	.142+00	.814-06	.288-02	-.567-05	-.251+00	-.837+00	-.505-01
11	.142+00	.814-06	-.288-02	.567-05	-.251+00	-.837+00	.505-01
12	.145+00	.779-06	-.849-02	.172-04	-.230+00	-.765+00	.153+00
13	.152+00	.717-06	-.137-01	.295-04	-.186+00	-.619+00	.262+00
14	.161+00	.537-06	-.179-01	.428-04	-.118+00	-.392+00	.380+00
15	.172+00	.457-06	-.210-01	.575-04	-.228-01	-.762-01	.510+00
16	.185+00	.247-06	-.224-01	.742-04	.102+00	.341+00	.656+00
17	.199+00	-.256-07	-.217-01	.929-04	.262+00	.875+00	.820+00
18	.211+00	-.377-06	-.182-01	.114-03	.492+00	.154+01	.100+01
19	.217+00	-.247-06	-.119-01	.137-03	.727+00	.235+01	.121+01
20	.174-07	-.997-05	-.234-01	-.109-03	.120+01	.334+01	.136+01

STA	U	V	W	PHI S	PHI T	PHI
1	-.445+01	.729+01	-.583-01	.159-01	.132+02	-.863+00
2	-.738+01	.517+01	-.439-01	-.549-02	.129+02	-.761+00
3	-.771+01	.339+01	-.295-01	-.496-02	.841+02	-.638+00
4	-.777+01	.191+01	-.177-01	-.404-02	.478+02	-.520+00
5	-.726+01	.745+00	-.819-02	-.322-02	.186+02	-.424+00
6	-.125+01	-.163+00	-.737-03	-.249-02	-.418+01	-.332+00
7	-.170+01	-.257+00	.493-02	-.185-02	-.214+02	-.249+00
8	-.850+00	-.135+01	.900-02	-.127-02	-.338+02	-.172+00
9	-.551+00	-.157+01	.115-01	-.744-03	-.418+02	-.101+00
10	-.185+00	-.187+01	.129-01	-.245-03	-.457+02	-.334-01
11	.185+00	-.187+01	.129-01	.245-03	-.457+02	.334-01
12	.551+00	-.157+01	.115-01	.744-03	-.418+02	.101+00
13	.850+00	-.135+01	.900-02	.127-02	-.338+02	.172+00
14	.170+01	-.257+00	.493-02	.185-02	-.214+02	.249+00
15	.125+01	-.163+00	-.737-03	.249-02	-.418+01	.332+00
16	.726+01	.745+00	-.819-02	.322-02	.186+02	.424+00
17	.777+01	.191+01	-.177-01	.404-02	.478+02	.520+00
18	.771+01	.339+01	-.295-01	.496-02	.841+02	.638+00
19	.738+01	.517+01	-.439-01	.549-02	.129+02	.761+00
20	.445+01	.729+01	-.583-01	-.159-01	.132+02	.863+00

MODAL OUTPUT FOR N= 20 FOLLOWS

STA	NS	N TH	N ST	Q S	M S	M T	M ST
1	-.379-03	-.529-04	.134-01	.296-03	.130+01	.334+01	-.890+00
2	.954-01	-.701-05	.919-02	-.249-03	.337+00	.112+01	-.548+00
3	.989-01	.169-05	.149-01	-.109-03	.295-01	.977-01	-.242+00
4	.783-01	.380-05	.121-01	-.322-04	-.772-01	-.244+00	-.742-01
5	.182-01	.327-05	.757-02	.101-05	-.819-01	-.273+00	-.144-03
6	.617-02	.210-05	.389-02	.109-04	-.593-01	-.198+00	.226-01
7	.594-03	.109-05	.159-02	.106-04	-.339-01	-.113+00	.227-01
8	-.177-02	.428-06	.433-03	.771-05	-.153-01	-.509-01	.159-01
9	-.174-02	.738-07	.147-04	.394-05	-.444-02	-.148-01	.860-02
10	-.158-02	-.720-07	-.319-04	.121-05	.234-03	.957-03	.265-02
11	-.158-02	-.720-07	.319-04	-.121-05	.234-03	.957-03	-.265-02
12	-.174-02	.738-07	-.147-04	-.394-05	-.444-02	-.148-01	-.860-02
13	-.177-02	.428-06	-.433-03	-.771-05	-.153-01	-.509-01	-.159-01
14	.594-03	.109-05	-.159-02	-.106-04	-.339-01	-.113+00	-.227-01
15	.617-02	.210-05	-.389-02	-.109-04	-.593-01	-.198+00	-.226-01
16	.182-01	.327-05	-.757-02	-.101-05	-.819-01	-.273+00	.143-03
17	.783-01	.380-05	-.121-01	.322-04	-.772-01	-.244+00	.742-01
18	.989-01	.170-05	-.149-01	.109-03	.295-01	.977-01	.241+00
19	.954-01	-.698-05	-.919-02	.249-03	.337+00	.112+01	.548+00
20	-.123-03	-.527-04	-.134-01	-.235-03	.130+01	.334+01	.890+00

STA	U	V	W	PHI S	PHI T	PHI
1	-.727+00	.180+01	-.587-01	-.511-01	.455+02	-.564+00
2	-.450+00	.617+00	-.293-01	-.106-01	.153+02	-.348+00
3	-.225+00	.534-01	-.254-02	-.466-02	.133+01	-.161+00
4	-.675-01	-.137+00	.309-02	-.135-02	-.333+01	-.542-01
5	-.108-01	-.149+00	.455-02	.793-04	-.373+01	-.501-02
6	.220-02	-.108+00	.338-02	.492-03	-.270+01	.116-01
7	.130-01	-.617-01	.197-02	.470-03	-.154+01	.132-01

8	.117-01	-.278-01	.906-03	.321-03	-.595+00	.962-02
9	.569-02	-.209-02	.283-03	.172-03	-.232+00	.530-02
10	.215-02	.527-03	.349-05	.525-04	.171-01	.168-02
11	-.215-02	.527-03	.349-05	-.525-04	.171-01	-.168-02
12	-.569-02	-.209-02	.283-03	-.172-03	-.232+00	-.530-02
13	-.117-01	-.278-01	.906-03	-.321-03	-.595+00	-.962-02
14	-.179-01	-.617-01	.197-02	-.470-03	-.154+01	-.132-01
15	-.920-02	-.103+00	.339-02	-.492-03	-.270+01	-.116-01
16	.186-01	-.149+00	.455-02	-.793-04	-.373+01	.501-02
17	.575-01	-.177+00	.380-02	.135-02	-.333+01	.542-01
18	.225+00	.534-01	-.254-02	.466-02	.173+01	.181+00
19	.459+00	.617+00	-.208-01	.106-01	.153+02	.348+00
20	.727+00	.182+01	-.587-01	.511-01	.455+02	.564+00

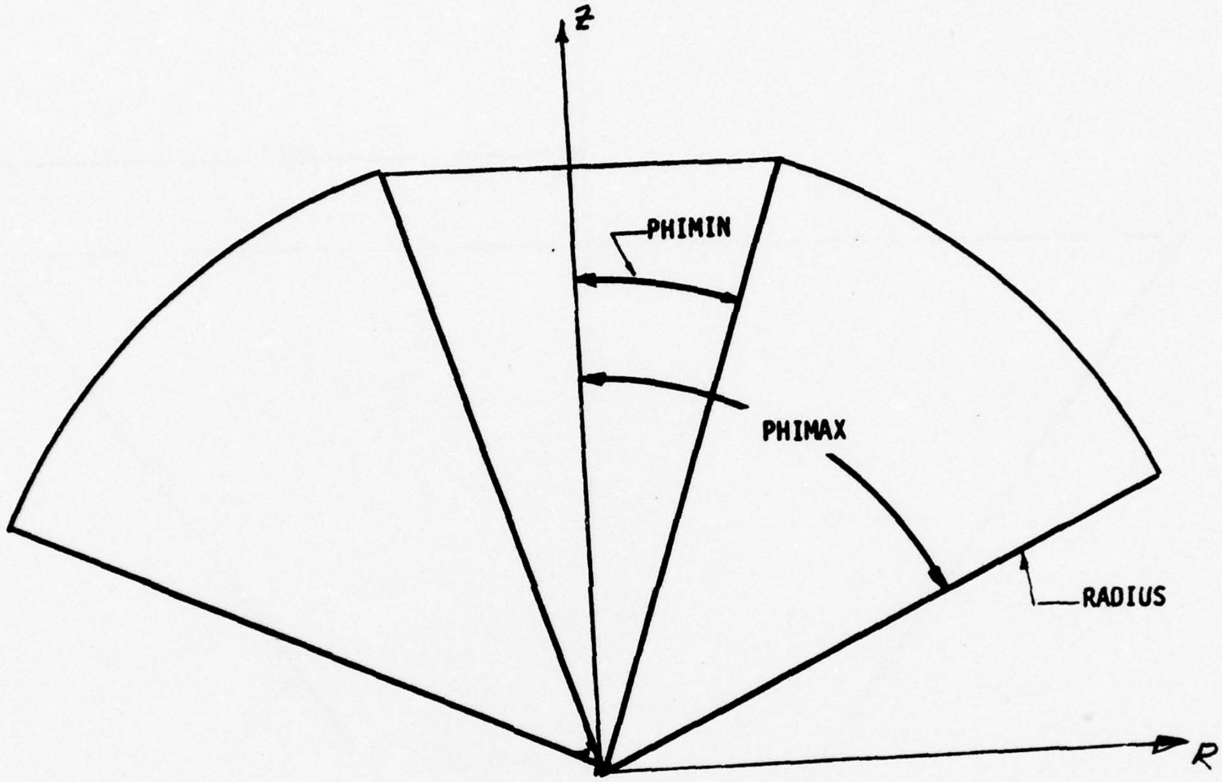


Figure 6.1 Spherical Shell Parameters

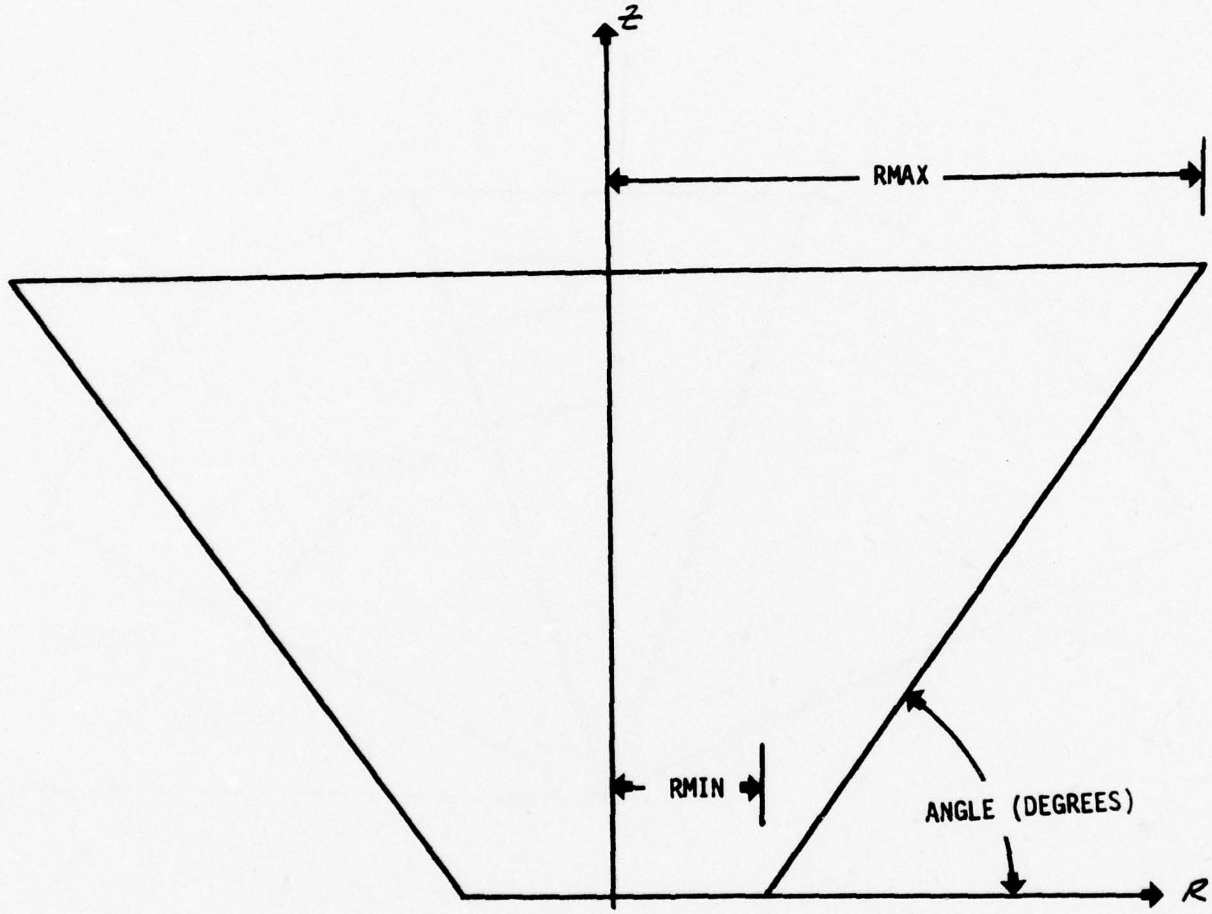


Figure 6.2 Conical Shell Parameters

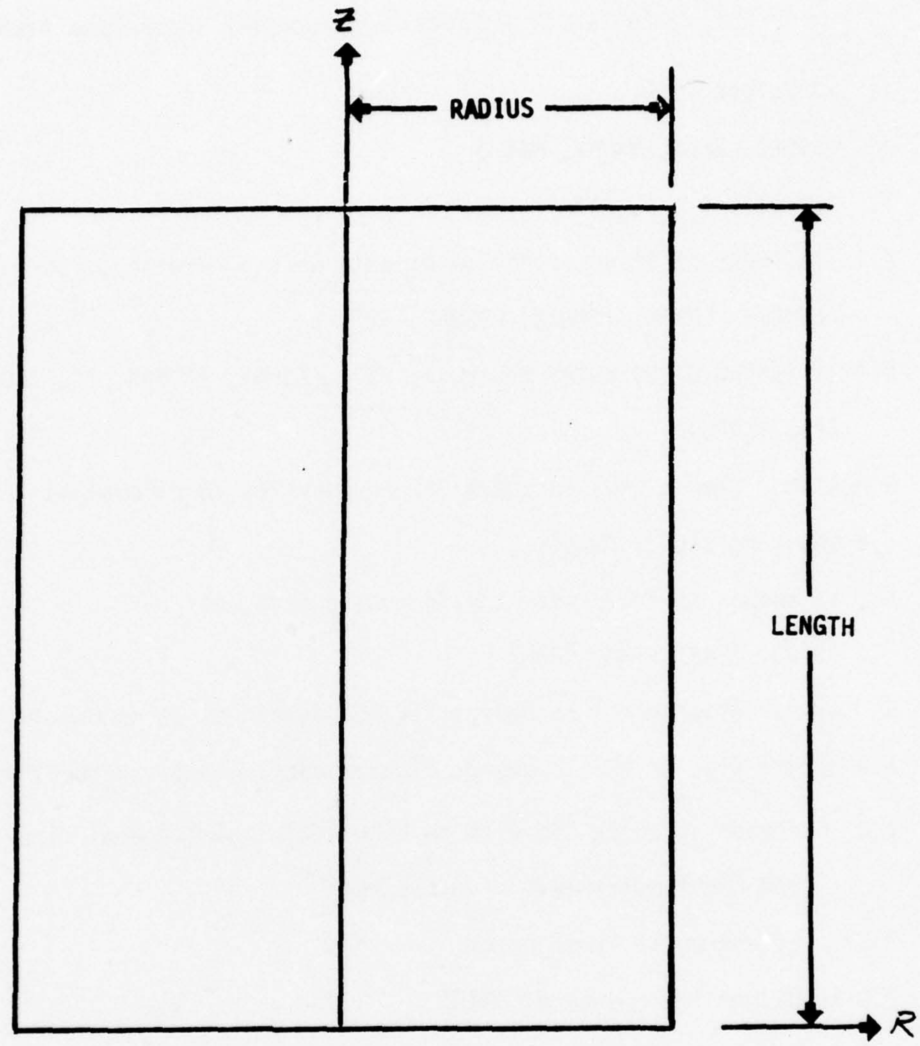


Figure 6.3 Cylindrical Shell Parameters

Table 6.1 - SATANS Preprocessor Input Data Elements

1. 72 Column Title

2. (ISORD, KMAX, MNMAX, MAXM)

3. (NN (I), I = 1, MAXM)

4.A If (ISORD.EQ.0) enter following data set; otherwise go to 4.B

(LSMAX, LCHMAX, ITRMAX, DELOAD, EPS)

4.B If (ISORD.GT.0) enter following data (LSMAX, ITRMAX, IC, TEEO, DELOAD, EPS, ITAPE)

5.A Answer (Yes or No) to query "Are properties in dimensional form?"

5.B Enter Poisson's Ratio

5.C If answer is "no" enter the following data set

(SIGO, ELAST, TKN, CHAR)

6. Answer (Yes or No) to query: "Is the output to be in nondimensional form?"

7.A Answer (Yes or No) to query: "Is the shell closed at the first station?"

7.B Answer to query "Do wish to enter only the diagonal elements of the OMEGA and LAMDA matrices?" (yes or no)

7.CY If answer is "yes" enter

7.C.1 Diagonal Elements of OMEGA

7.C.2 Diagonal Elements of LAMDA

7.CN If answer is "no" enter

7.C.1 All elements of OMEGA (by row)

7.C.2 All elements of LAMDA (by row)

7.C.3 For either 'yes' or 'no' enter elements of EL-VECTOR

8.B Same as 7.B

8.C Same as 7.C

Table 6.1 (Concluded)

9. (NTHMAX, IFREQ, IPRINT, IMØDE)

10. If (NTHMAX.GT.0) enter data set (ANGLE(I), I = 1, NTHMAX)

11. Enter GEOMETRY CODE (IGEOM)

    .EQ.1 Sphere

    .EQ.2 Cone

    .EQ.3 Cylinder

    .EQ.4 General Shell

11.1 If (IGEOM.EQ.1)

(PHIMIN, PHIMAX, RADIUS)

11.2 If (IGEOM.EQ.2)

(RMIN, RMAX, ANGLE)

11.3 If (IGEOM.EQ.3)

(RADIUS, LENGTH)

11.4 If (IGEOM.EQ.4)

11.4A DEL

11.4B KMAX SETS (R, OMT, OMXI, DEOMX, GAM)

12. Answer to query "Do you want a summary of the input data?" (Yes or no)

13. Answer to query "Is there another case?" (Yes or no)

Table 6.2 COMMON Data Elements

COMMON	Data Elements
/BL32/	TKN, ELAST, CHAR, SIGO
/BL15/	NU
/BL17)	DEL
/IBL2/	NN(10)
/IBL1)	MNMAX
/BL3/	PR(10), PX(10), PT(10)
/IBL4/	KMAX, KL
/BL5/	TT(10), EMT(10), DT(10), DMT(10)
/BL101/	Z0(4,220), Z2(4,220), Z3(4,220)
/BL100/	SORD, TEEO
/IBL9/	MAXM

7.0 SAASIII

7.1 Introduction

SAASIII, is a general purpose finite element program for the stress analysis of axisymmetric and plane solids with different orthotropic temperature-dependent material properties in tension and compression. The program theoretical and user information are presented by reference (11).

This report describes the execution of

(1) An interactive input data preprocessor which produces the formatted input data file for the SAASIII analysis program.

(2) The execution of the analysis program on the University of Maryland UNIVAC 1108.

7.2 SAASIII

The SAAS IDP operates in the Demand mode and allows the user to input unformatted data in a program-controlled logical sequence. The IDP performs some elementary error checks and writes a file which contains the formatted input modes, interactive or data file; and, further allows the user to control the amount of computer generated prompting in the interactive mode.

In the interactive mode the IDP issues prompting information which is displayed by the terminal device. The user then inputs the requested information directly by means of the keyboard in unformatted form; i.e., the data elements are delimited by commas. This interaction continues until all of the input requirements have been satisfied. In the data file mode the user prepares the unformatted input to the IDP; and, then informs the IDP the name of the data file. The IDP then reads the input data directly from the data file in exactly the same sequence as the interactive mode; but, completely bypasses the prompting

In either mode the sequence required for the IDP input is shown by Table 7.1. For the most part the input data elements have the same names and meaning as those variables defined in the program users manual. However it is recommended that the interactive mode be executed initially with maximum prompting in order to completely define each data element.

The user will note that the IDP does not request all of the data items described by the user's manual. Specifically the IDP does not request any parameters which are associated with plotting.

7.2.1 Interactive Mode

In the interactive mode the IFP sets up a question-answer dialogue with the user. The IDP defines a data set to be input and then accepts the input in unformatted form directly from the terminal keyboard. The SAASIII IDP has two levels of prompting which are controlled by user request. The minimum prompting mode requests data elements by displaying the data element mneumonics; while the maximum prompting mode defines each of the data elements.

In either the interactive or the data file mode the IDP creates a formatted input file for the SAASIII analysis program. This file which is stored on a mass storage device must be identified by means of a file name. The program thus requests the user to enter a name for the file. The IDP will then catalog the file; and, an error will result if the file already exists. The user should note that the file is cataloged as a private file and may be named using read keys as follows:

QUALIFIER*NAME/KEY1/KEY2/

where KEY1 is the write key; KEY2 is the read key. The user is cautioned to retain these keys in a secure place, if used.

7.2.2 Data File Mode

In this mode the user prepares a data file containing the responses to the IDP either off-line using a paper tape or tape cassette; or on-line using the text editor. The data elements are described by Table 7.1. The purpose of this input mode is to allow the user to prepare an input file for the IDP so that the prompting produced by the IDP can be bypassed.

The IDP will query the user to determine if the data file mode is to be used. If so, the user is requested to enter the name of the file containing the prepared file of unformatted input. The IDP will then read from this file to satisfy read requests completely by-passing the interactive prompting.

Occasionally the user may make an error in preparing the data file which will cause a read-error in the IDP, and an error exit. The information printed by the system at this time will be of little assistance in identifying the data elements which are in error. A recommended procedure at this point is to place the IDP in the prompting mode; but to cause the IDP to read the pre-created data file. This can be accomplished by responding "NO" to the question "DO YOU WANT TO ENTER DATA FROM A DATA FILE?". Then in response to the first prompt for data the data file is added by the command

@ADD QUALIFIER*NAME

The IDP now prints all prompting, but reads the data from the data file. It is then possible to identify the data elements in error by noting at which point the error exists.

7.3 Examples

The SAASIII examples are taken from reference (11).

7.3.1 Hollow Cylinder with Uniform Internal and External Pressure (Lame' Cylinder)

The four element idealization of the cylinder is shown by Figure

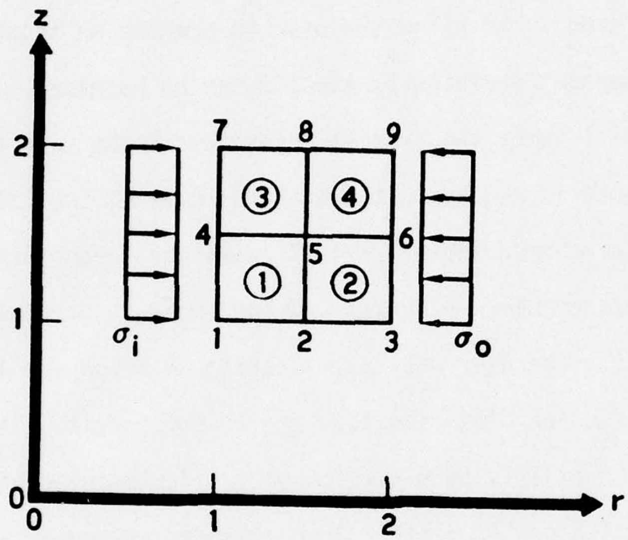


Figure 7.1 Four Element Idealization of Cylinder

The loads and physical parameters are as given below

σ_i = 5000 psi

σ_o = 10,000 psi

E = 3×10^6 psi

r_i = 1 in

r_o = 2 in

ν = .3

7.3.1.1 Interactive Mode

The interactive input mode for the creation of the formatted SAASIII input file is shown below, where the formatted file is to be called LAME

```
UM0010

UCM 1108 31.159B:D

ACCOUNT NUMBER? @RUN SHAFER,301148HARRY,SCHAEFFER,5,500
PASSWORD?
[redacted]

TAPE USERS SEE 'NEWS,F OVERDUE-TAPE'
RUNID: SHAFES    05/08/74  18:12:33
@QUAL SYMPOSIUM
NEW WORKSPACE CREATED
READY
@XQT *PREPROCESSOR.SAAS
            *** INPUT DATA PREPROCESSOR FOR SAAS3 ***


 ENTER NAME OF OUTPUT DATA FILE
LAME


 DO YOU WANT TO ENTER DATA FORM A DATA FILE (YES OR NO)
NO
 DO YOU WANT MINIMUM PROMPTING (YES OR NO)
NO
 HOW MANY CASES?
1
 WHAT IS THE TITLE FOR THIS CASE?
LAME CYLINDER
          -CONTROL PARAMETERS-

 ENTER PLANE STRESS/STRAIN OPTION
     .EQ.0 NEITHER
     .EQ.1 PLANE STRAIN
     .EQ.2 PLANE STRESS
0
 ENTER NUMBER OF NON-LINEAR APPROXIMATIONS
0
 ENTER THE MESH GENERATION PARAMETER
     .EQ.1 FOR MESH GENERATION
1
 ENTER THE DATA SET (ITCARDS,IPCARDS)
     .EQ.0 DATA ON NODE CARDS
     .EQ.-1 DATA ON TAPE14
     .EQ.-2 CONSTANT PROPERTIES
0,0
 ENTER DATA SET (IMAT,IPRESS,ISHEAR)
     IMAT  =NUMBER OF DIFFERENT MATERIALS
     IPRESS=NUMBER OF BOUNDARY PRESSURE CARDS
     ISHEAR=NUMBER OF BOUNDARY SHEAR CARDS
1,4,0
```

```
ENTER DATA SET (TREF,NTC,NFREQ)
     TREF =REFERENCE TEMPERATURE
     NTC  =NUMBER OF TENSION/COMPRESSION APPROX
     NFREQ (CALCULATE FREQUENCY IF .EQ.1)
10.?
0.,0,0
 -MESH GENERATION PARAMETERS-

 ENTER THE DATA SET:
 (MAXI, MAXJ, NLSEG, NBC, NMAT, NIT, PCI, PCJ, ICM, JCM)
      MAXI - MAX I
      MAXJ - MAX J
      NLSEG - NO OF LINE SEGMENT CARDS
      NBC  - NO OF BOUNDARY CONDITIONS CARDS
      NMAT - NO OF MAT BLOCK CARDS
      NIT  - NO OF ITERATIONS
      PCI  - POLAR PARAMETER I
      PCJ  - POLAR PARAMETER J
      ICM  - I CURV MOD
      JCM  - J CURV MOD
3,3,4,2,1,0,0,0,0,0
 -LINE SEGMENT INFORMATION-

 POINT COORDINATES IN THE (I,J)-SPACE AND (R,Z)-SPACE ARE TO BE
 ENTERED ACCORDING TO THE VALUE OF A CONTROL PARAMETER, N :
      IF .EQ. 0 ENTER ONLY FIRST POINT TO DEFINE A POINT
      IF .EQ. 1 ENTER FIRST AND SECOND TO DEFINE A LINE
      IF .EQ. 2 ENTER FIRST AND SECOND TO DEFINE A DIAGONAL
      IF .EQ. 3 ENTER THREE POINTS TO DEFINE CIRCULAR ARC WITH
                FIRST AND LAST DEFINING ENDS
      IF .EQ. 4 ENTER (R,Z) ONLY TO DEFINE ARC WITH THIRD POINT AS CENTE
R
 ENTER   4 DATA SETS
 (N)
 (I1,J1,R1,Z1,....,I3,J3,R3,Z3)
1
1,1,1.,1.,1,3,1.,2.
1
1,3,1.,2.,3,3,2.,2.
1
3,3,2.,2.,3,1,2.,1.
1
3,1,2.,1.,1,1,1.,1.
 -BOUNDARY CONDITION INFORMATION-

 DATA IS READ TO ASSIGN BOUNDARY CONDITION TO A BLOCK OF ELEMENTS
 BOUNDED BY I1,I2,J1,J2.
 ENTER .. 2 DATA SETS (I1,I2,J1,J2,CODE,XR,XZ)
     I1=I2 OR J1=J2 TO DEFINE A LINE
     I1=I2 AND J1=J2 TO DEFINE A POINT
     XR AND XZ ARE FORCE AND/OR DISPLACEMENTS ACCORDING TO CODE VALUE
      AS FOLLOWS:

     CODE      XR        XZ
      0      R-LOAD    Z-LOAD
      1      R-DISP    Z-LOAD
      2      R-LOAD    Z-DISP
      3      R-DISP    Z-DISP
```

```
1,3,1,1,8,0.,0.
1,3,3,3,8,0.,0.
 -MATERIAL BLOCK INFORMATION-

 ENTER    1 DATA SETS (MATID,MINI,MAXI,MINJ,MAXJ,ALPHA)
      MATID =MATERIAL I.D.
      MINI= MINIMUM I
      MAXI= MAXIMUM I
      MINJ= MINIMUM J
      MAXJ= MAXIMUM J
      ALPHA=MATERIAL PROPERTY INCLINATION ANGLE
1,1,3,1,3,0.
 -MATERIAL PROPERTY INFORMATION-

 THE PROGRAM ALLOWS FOR THE GENERAL CASE OF A TEMPERATURE VARYING
 ORTHOTROPIC MATERIAL WITH DIFFERENT PROPERTIES IN TENSION AND
 COMPRESSION. FOR THE GENERAL CASE THE MATERIAL PROPERTY INFORMATION
 IS TO BE ENTERED USING FREE FORMAT IN EXACTLY THE ORDER SPECIFIED IN
 THE SAAS-III USERS MANUAL; WITH EACH LOGICAL CARD TERMINATED BY A
 CARRIAGE RETURN.
   FOR THE CASE OF AN ISOTROPIC MATERIAL HAVING THE SAME PORPERTIES
 IN TENSION AND COMPRESSION YOU MAY ELECT TO INPUT A MINIMUM OF DATA
 DO YOU WISH TO ELECT THE LATER OPTION?
YES
 FOR EACH OF    1 MATERIALS ENTER THE FOLLOWING DATA SET
      (MID,NT,RHO,TEX,POR)
      MID= MATERIAL I.D. NUMBER
      NT = NUMBER OF TEMPERATURES AT WHICH MATL PROPERTIES ARE DEFINED
      RHO= MATL DENSITY (0 IF STATIC PROBLEM)
      TEX= THERMAL EXPANSION PARAMETER (IF 1, FREE THERMAL STRAIN,
 IF 0, COEFFICIENT OF THERMAL EXPANSION)
      POR= EFFECTIVE POROCITY
 FOLLOWED BY THE DATA SET
 ((T(I),E(I),NU(I),ALPHA(I),SIGMA(I),RATIO(I)),I =1,NT)
       ALPHA = FREE THERMAL STRAIN OR COEF OF THERMAL EXPANSION
 FOR TEX = 1 OR 0; RESPECTIVELY
       SIGMA = YIELD STRESS
       RATIO = RATIO OF EFFECTIVE PLASTIC TO ELASTIC MODULUS
1,1,0/-,,0.,0.
0.,3.E6,.3,0.,0.,0.
 -BOUNDARY PRESSURE INFORMATION-

 ENTER    4 DATA SETS (I,J,P)
      I =NODE I
      J =NODE J
      P =NORMAL PRESSURE
7,4,5000.
4,1,5000.
3,6,5000.
6,9,10000.
 DO YOU WANT A SUMMARY OF INPUT DATA?
N?
YES
```

-SUMMARY OF INPUT DATA-

NUMBER OF CASES = 1

```
 LAME CYLINDER
SOLUTION OPTION                          0
     PLANE STRAIN IF 1
     PLANE STRESS IF 2
START OPTION                             1
     START AT BEGINNING IF 1
     START WITH CONTOUR PLOT IF 2
STOP OPTION                              0
     AFTER MESH PLOT IF 1
     BEFORE CONTOUR PLOT IF 2
DEFORMED GRID PLOT IF 1                  0
PLOT PARAMETER                           0
NO OF NONLINEAR APPROX                   0
MESH GENERATION IF 1                     1
NO OF TEMPERATURE CARDS                  0
NO OF NODAL POINTS                       0
NO OF ELEMENTS                           0
NO OF PRESSURE CARDS                     0
NO OF MATERIALS                          1
NO OF BOUNDARY PRESSURE CARDS            4
NO OF BOUNDARY SHEAR CARDS               0
REFERENCE TEMPERATURE                   0.
NO OF TEN./COMP. APPROX                  0
NATURAL FREQ PARAMETER                   0
-MESH GENERATION CONTROL-

MAXI =       3
MAXJ =       3
NO OF LINE SEGS =      4
NO B.C. CARDS =      2
NO OF MATL BLOCKS =      1
NO OF ITERATIONS =      0
PCPI =          0.
PCPJ =          0.
I-CURV =      0
J-CURV =      0
-LINE SEGMENT DATA-
```

COORDS OF 1ST POINT				COORDS OF 2ND POINT				COORDS OF 3RD POINT				PARAM
I	J	R	Z	I	J	R	Z	I	J	R	Z	
1	1	1.000	1.000	1	3	1.000	2.000	0	0	.000	.000	1
1	3	1.000	2.000	3	3	2.000	2.000	0	0	.000	.000	1
3	3	2.000	2.000	3	1	2.000	1.000	0	0	.000	.000	1
3	1	2.000	1.000	1	1	1.000	1.000	0	0	.000	.000	1

-BOUNDARY CONDITION DATA-

LI	UI	LJ	UJ	CODE	R	XZ
1	3	1	1	2.	0.	0.
1	3	3	3	2.	0.	0.

```
-MATERIAL BLOCK ASSIGNMENT-
MATID LI    UI    LJ    UJ        ALPHA

   1    1    3    1    3          0.
-MATERIAL PROPERTY INFORMATION-

THERE IS (ARE)  1 DIFFERENT MATERIAL GROUPS

DATA FOR MATERIAL NUMBER  1 FOLLOWS
    MATERIAL I.D. NUMBER----------------------- 1
    NO OF TEMP. AT WHICH PROPERTIES ARE DEFINED 1
    MASS DENSITY------------------------------- .00000
    THERMAL EXPANSION PARAMETER---------------- .00000
    EFFECTIVE POROSITY------------------------- .00000
    MATERIAL SYMMETRY PARAMETER---------------- 2
TEMPERATURE =  .00000000

        TENSILE     COMPRESSIVE         THERM/YIELD
E-N     .30000+07    .30000+07          ALPHA-N    .00000
E-N     .00000       .00000             ALPHA-N    .00000
E-TH    .00000       .00000             ALPHA-T    .00000
NU-NN   .30000       .30000             SIGMA-N    .00000
NU-NT   .00000       .00000             SIGMA-N    .00000
NU-NT   .00000       .00000             SIGMA-T    .00000
G-NN    .00000       .00000             PENR       .00000
-BOUNDARY PRESSURE-

NODE-I NODE-J  PRESSURE

     7      4    .50000+04
     4      1    .50000+04
     3      6    .50000+04
     6      9    .10000+05
END OF CASE
END OF DATA


NORMAL EXIT.  EXECUTION TIME:          2016 MILLISECONDS.
```

We note from the summary of the input data that boundary pressure associated with point (3,6) is incorrect; the value 5000. should be 10000. We will therefore edit the file LAME.*, and change the value of pressure.*

```
*ED LAME.
ED 86D 05/08-12:37-(00):F
EDIT
*P 30

    1
 LAME CYLINDER
 0  1      0  0     0    1    0    0    0 0 1    4    0  .00     0    0
    3    3    4    2    1    0 .00000      .00000       0    0
  1  1 1.00     1.00    1  3 1.00     2.00      0  0 .000    .000      1
  1  3 1.00     2.00    3  3 2.00     2.00      0  0 .000    .000      1
  3  3 2.00     2.00    3  1 2.00     1.00      0  0 .000    .000      1
  3  1 2.00     1.00    1  1 1.00     1.00      0  0 .000    .000      1
     1    3     1    1 2.0000     .00000     .00000
     1    3     3    3 2.0000     .00000     .00000
     1    1     3    1    3   .000
     1    1 .00000    .00000     .00000        2
 .00000      .30000+07 .00000     .00000     .30000     .00000     .00000    .
00000
             .30000+07 .00000     .00000     .30000     .00000     .00000    .
00000
             .00000    .00000     .00000     .00000     .00000     .00000    .
00000
    7     4 5000.0
    4     1 5000.0
    3     6 5000.0
    6     9 10000.
END OF CASE
END OF DATA
EOF AT LINE 21
*
```

We can now find and change the appropriate line of LAME. by means of the following edit commands

```
L 3 6 5
*
    3     6 5000.0
*C /5/10/
    3     6 10000.0
*E
END EDIT 21 LINES OUTPUT
```

7.3.1.2 Data File Mode

The input data for the SAASIII will be created in the element LAME of the file SAASPROBS by using the text editor. First a file SAASPROBS must be created by using the system commands:

```
@CAT, UP   SAASPROBS.
@FREE  SAASPROBS.
@ASG,A  SAASPROBS.
```

The data is now input by means of the text editor as follows.

```
@ED  SAASPROBS.LAME
INPUT
```

(The input data is now shown)

The IDP is now executed in the data file mode as follows, where, again we assume that LAME contains the formatted output file.

```
@XQT *PREPROCESSOR.SAAS
FILE DELETED
              *** INPUT DATA PREPROCESSOR FOR SAAS3 ***

 ENTER NAME OF OUTPUT DATA FILE
LAME

 DO YOU WANT TO ENTER DATA FORM A DATA FILE (YES OR NO)
YES

 ENTER NAME OF INPUT  DATA FILE
SAASPROBS.LAME
```

```
-SUMMARY OF INPUT DATA-

NUMBER OF CASES =      1

 LAME CYLINDER
SOLUTION OPTION                          0
     PLANE STRAIN IF 1
     PLANE STRESS IF 2
START OPTION                             1
     START AT BEGINNING IF 1
     START WITH CONTOUR PLOT IF 2
STOP OPTION                              0
     AFTER MESH PLOT IF 1
     BEFORE CONTOUR PLOT IF 2
DEFORMED GRID PLOT IF 1                  0
PLOT PARAMETER                           0
NO OF NONLINEAR APPROX                   0
MESH GENERATION IF 1                     1
NO OF TEMPERATURE CARDS                  0
NO OF NODAL POINTS                       0
NO OF ELEMENTS                           0
NO OF PRESSURE CARDS                     0
NO OF MATERIALS                          1
NO OF BOUNDARY PRESSURE CARDS            4
NO OF BOUNDARY SHEAR CARDS               0
REFERENCE TEMPERATURE                   0.
NO OF TEN./COMP. APPROX                  0
NATURAL FREQ PARAMETER                   0
-MESH GENERATION CONTROL-

MAXI =       3
MAXJ =       3
NO OF LINE SEGS =      4
NO B.C. CARDS =      2
NO OF MATL BLOCKS =      1
NO OF ITERATIONS =     0
PCPI =          0.
PCPJ =          0.
I-CURV =     0
J-CURV =     0
-LINE SEGMENT DATA-
```

COORDS OF 1ST POINT				COORDS OF 2ND POINT				COORDS OF 3RD POINT				PARAM
I	J	R	Z	I	J	R	Z	I	J	R	Z	
1	1	1.000	1.000	1	3	1.000	2.000	0	0	.000	.000	1
1	3	1.000	2.000	3	3	2.000	2.000	0	0	.000	.000	1
3	3	2.000	2.000	3	1	2.000	1.000	0	0	.000	.000	1
3	1	2.000	1.000	1	1	1.000	1.000	0	0	.000	.000	1

-BOUNDARY CONDITION DATA-

LI	UI	LJ	UJ	CODE	R	XZ
1	3	1	1	2.	0.	0.
1	3	3	3	2.	0.	0.

```
-MATERIAL BLOCK ASSIGNMENT-
MATID LI   UI   LJ   UJ      ALPHA

  1   1    3    1    3        0.
-MATERIAL PROPERTY INFORMATION-

THERE IS (ARE)  1 DIFFERENT MATERIAL GROUPS


DATA FOR MATERIAL NUMBER  1 FOLLOWS
    MATERIAL I.D. NUMBER------------------------ 1
    NO OF TEMP. AT WHICH PROPERTIES ARE DEFINED  1
    MASS DENSITY-------------------------------- .00000
    THERMAL EXPANSION PARAMETER----------------- .00000
    EFFECTIVE POROSITY-------------------------- .00000
    MATERIAL SYMMETRY PARAMETER----------------- 2
TEMPERATURE =  .00000000

         TENSILE    COMPRESSIVE          THERM/YIELD
E-M      .30000+07   .30000+07            ALPHA-M    .00000
E-N      .00000      .00000               ALPHA-N    .00000
E-TH     .00000      .00000               ALPHA-T    .00000
NU-MN    .30000      .30000               SIGMA-M    .00000
NU-MT    .00000      .00000               SIGMA-N    .00000
NU-NT    .00000      .00000               SIGMA-T    .00000
G-MN     .00000      .00000               PEMR       .00000
-BOUNDARY PRESSURE-


NODE-I NODE-J  PRESSURE

    7     4    .50000+04
    4     1    .50000+04
    3     6    .10000+05
    6     9    .10000+05
END OF CASE
END OF DATA



NORMAL EXIT.  EXECUTION TIME:        2149 MILLISECONDS.
```

7.3.1.3 Analysis Program Execution

Using one of the two modes in the IDP we have created a file LAME, which contains the formatted input data for SAASIII. The analysis program requires more core than is normally available for demand execution. The program will thus be sent to the batch queue for execution by means of the @START command. First, however, we must create a run stream to execute the program. Let's call this run stream START-SAAS we then proceed as follows:

```
@CAT,UP  START-SAAS.
@FREE  START-SAAS.
@ASG,A  START-SAAS.
```

The output of the SAASIII program will be copied to SAASOUT using the following run stream

```
@ED  START-SAAS.
INPUT
#RUN  runid  ,  acct no  , SYMPOSIUM, 5, 500
#CAT,U  SAASOUT
#FREE  SAASOUT.
#ASG,A  SAASOUT.
#BRKPT PRINT$/SAASOUT
#XQT  PROGRAM.SAAS
#ADD  LAME.
#FIN
```

The #'s are now changed to @'s by using the change feature of the editor.

After satisfying yourself that the file is correct it is submitted to the batch queue by the command

@START START-SAAS.

7.3.1.4 Analysis program Output Listing

The listing of the results of SAASIII for the Lame' cylinder problem is as follows.

```
NCASE= 1

         10        20        30        40        50        60        70
1234567890123456789012345678901234567890123456789012345678901234567890123
LAME CYLINDER
 0  1    0    0    0    1    0    0    0  0 1    4    0 .00    0    0
    3    3    4    2    1    0 .00000    .00000         0    0
  1  1 1.00    1.00    1  3 1.00    2.00    0  0 .000    .000         1
  1  3 1.00    2.00    3  3 2.00    2.00    0  0 .000    .000         1
  3  3 2.00    2.00    3  1 2.00    1.00    0  0 .000    .000         1
  3  1 2.00    1.00    1  1 1.00    1.00    0  0 .000    .000         1
    1    3    1    1 2.0000    .00000    .00000
    1    3    3    3 2.0000    .00000    .00000
    1    1    3    1    3   .000
    1    1 .00000    .00000    .00000         2
 .00000    .30000+07 .00000    .00000    .30000    .00000    .00000    .0


    3    4 5000.0
    4    1 5000.0
    3    6 10000.
    6    9 10000.
END OF CASE
```

```
    CYLIN

START PARAMETER---------------   1

STOP PARAMETER----------------   0

IF 1, PLOT DEFLECTIONS           0

IF 1, SMALL PLOT. IF 2, LARGE

PLOT. OTHERWISE NO PLOT.------   0

NUMBER OF APPROXIMATIONS------   0

IF 1, GENERATE MESH-----------   1

NUMBER OF TEMPERATURE CARDS---   0

NUMBER OF NODAL POINTS--------   0

NUMBER OF ELEMENTS------------   0

NUMBER OF INTERNAL PRESSURES--   0

NUMBER OF MATERIALS-----------   1

NUMBER OF EXTERNAL PRESSURES--   4

NUMBER OF SHEAR CARDS---------   0

REFERENCE TEMPERATURE---------     .0000


NUMBER OF TENSION-COMPRESSION APPROXIMATIONS----    0
```

```
MESH GENERATION INFORMATION

MAXIMUM VALUE OF I IN THE MESH--------  3

MAXIMUM VALUE OF J IN THE MESH--------  3

NUMBER OF LINE SEGMENT CARDS----------  4

NUMBER OF BOUNDARY CONDITION CARDS----  2

NUMBER OF MATERIAL BLOCK CARDS--------  1

NUMBER OF ITERATIONS------------------  0

POLAR COORDINATE PARAMETER I----------     .0000

POLAR COORDINATE PARAMETER J----------     .0000

I CURVATURE MODIFICATION--------------  0

J CURVATURE MODIFICATION--------------  0


INPUT    I1   J1     R1        Z1     I2   J2     R2        Z2     I3   J3     R3       Z3
          1    1   1.000    1.000     1    3   1.000    2.000     0    0    .000      .0
DI=  0.  DJ=  2.  DIFF=  2.  RINC=     .000  ZINC=     .500  ITER=  1  IINC=
  I     J          AR         AZ
  1     2       1.000      1.500

INPUT    I1   J1     R1        Z1     I2   J2     R2        Z2     I3   J3     R3       Z3
          1    3   1.000    2.000     3    3   2.000    2.000     0    0    .000      .0
DI=  2.  DJ=  0.  DIFF=  2.  RINC=     .500  ZINC=     .000  ITER=  1  IINC=
  I     J          AR         AZ
  2     3       1.500      2.000

INPUT    I1   J1     R1        Z1     I2   J2     R2        Z2     I3   J3     R3       Z3
          3    3   2.000    2.000     3    1   2.000    1.000     0    0    .000      .0
DI=  0.  DJ=  2.  DIFF=  2.  RINC=     .000  ZINC=    -.500  ITER=  1  IINC=
  I     J          AR         AZ
  3     2       2.000      1.500

INPUT    I1   J1     R1        Z1     I2   J2     R2        Z2     I3   J3     R3       Z3
          3    1   2.000    1.000     1    1   1.000    1.000     0    0    .000      .0
DI=  2.  DJ=  0.  DIFF=  2.  RINC=    -.500  ZINC=     .000  ITER=  1  IINC= -
  I     J          AR         AZ
  2     1       1.500      1.000

COORDINATES CALCULATED AFTER 43 ITERATIONS
```

I	J	NP	TYPE	R-ORDINATE	Z-ORDINATE	R LOAD OR DISPLACEMENT
1	1	1	2.0	1.000	1.000	.0000000
2	1	2	2.0	1.500	1.000	.0000000
3	1	3	2.0	2.000	1.000	.0000000
1	2	4	.0	1.000	1.500	.0000000
2	2	5	.0	1.500	1.500	.0000000
3	2	6	.0	2.000	1.500	.0000000
1	3	7	2.0	1.000	2.000	.0000000
2	3	8	2.0	1.500	2.000	.0000000
3	3	9	2.0	2.000	2.000	.0000000

EL	I	J	K	L	MATERIAL	ANGLE	TEMPERATURE	PRESSURE
1	1	2	5	4	1	.0	.000	.000
2	2	3	6	5	1	.0	.000	.000
3	4	5	8	7	1	.0	.000	.000
4	5	6	9	8	1	.0	.000	.000

```
MATERIAL = 1      NO. OF TEMPERATURES AT WHICH PROPERTIES ARE SPECIFIED = 1
   MASS DENSITY =   .0000          POROSITY =   .0000
   ANISOTROPY PARAMETER =    2

TEMP=    0.
TENSILE PROPERTIES
    EMT=  3000000.  ENT=  3000000.  ETT=  3000000.  NUMNT= .300  NUMTT= .300
COMPRESSIVE PROPERTIES
    EMC=        0.  ENC=        0.  ETC=        0.  NUMNC= .000  NUMTC= .000
THERMAL AND YIELD PROPERTIES
    AM=    .000    AN=    .000    AT=    .000    YM=        0. YN=        0. YT=
```

PRESSURE BOUNDARY CONDITIONS

I	J	INTENSITY
7	4	5000.0
4	1	5000.0
7	6	10000.0
[illegible]	[illegible]	10000.0

NODAL POINT	UR	UZ
1	-.4857280-02	.0000000
2	-.4922751-02	.0000000
3	-.5459964-02	.0000000
4	-.4853257-02	-.1132139-07
5	-.4922826-02	-.5579770-09
6	-.5459974-02	.3874430-08
7	-.4853380-02	.0000000
8	-.4922751-02	.0000000
9	-.5459971-02	.0000000

EL	R	Z	SIGMAR	SIGMAZ	SIGMAT	SIGMARZ	SIGMAMAX	SIGMAMIN	AN
1	1.25	1.25	-7329.	-7009.	-16032.	-0.	-7009.	-7329.	-89
2	1.75	1.25	-9473.	-6994.	-13840.	0.	-6994.	-9473.	90
3	1.25	1.75	-7329.	-7008.	-16032.	0.	-7008.	-7329.	89
4	1.75	1.75	-9474.	-6994.	-13840.	-0.	-6994.	-9474.	-90

EL	EPSR	EPSZ	EPST	EPSRZ	EPSMAX	EPSMIN	ANGLE	EPSM	EPSN
1	-.014	-.000	-.391	-.000	-.000	-.014	.00	-.014	-.000
2	-.107	.000	-.297	.000	.000	-.107	.00	-.107	.000
3	-.014	.000	-.391	.000	.000	-.014	.00	-.014	.000
4	-.107	-.000	-.297	-.000	-.000	-.107	.00	-.107	-.000

TABLE 7.1 SAASIII Preprocessor Input Data Elements

1. Title (.LE.72 Characters)

2. Plane stress/strain option

3. Number of non-linear approximations

4. Mesh generation parameter (MGP)

5. (NODES, NELMTS)

6. (ITCARDS, IPCARDS)

7. (IMAT, IPRESS, ISHEAR)

8. (TREF, NTC, NFREQ)

9. IF (NFREQ.EQ.0) enter no data, otherwise enter (R,Z)

10. IF (MGP.NE.1) enter no data, otherwise enter the data set

10.A (MAXI, MAXJ, NLSEG,NBC,NMAT,NIT,PCI,PCJ,ICM,JCM)

Enter NLSEG sets as follows

10.B.1 N

10.B.2 (I_1, J_1, R_1, Z_1, ..., I_3, J_3, R_3, Z_3)

Enter NBC data sets as follows

10.C (I1, I2, J1, J2, ICODE, XR, XZ)

Enter NMAT data sets as follows

10.D (MATID, MINI, MAXI, MINJ, MAXJ, ALPHA)

11. IF(ITCARD.EQ.0) enter no data otherwise

11.A.1 if (ITCARD.GT.0) enter ITCARD sets (R,Z,T)

11.A.2 if (ITCARD.EQ.-2) enter (T)

12. IF (IPCARD.EQ.0) enter no data, otherwise

12.A.1 if (IPCARD.GT.0) enter IPCARD sets) (R,Z,P)

12.A.2 if (IPCARD.EQ.-2) enter P

IF (MGP.NE.1) proceed to item 15

TABLE 7.1 (Continued)

13. Enter NODES data sets (NODE, CODE, R, Z, XR, XZ, T (if ITCARD.EQ.0), PC if IPCARD.EQ.0)).

14. Answer query "Do you input minimum data?"

14.A YES Enter IMAT data sets

(MID, NT, RHO, TEX, POR)

(T_i, E_i, NU_i, $ALPHA_i$, $SIGMA_i$, $RATIO_i$) i = 1, NT

14.A NO

Enter IMAT data sets

(MID, NT, RHO, TEX, POR)

followed by NT data sets for each MID:

$(T, E_{Mt}, E_{nt}, E_{\theta t}, \nu_{MNt}, \nu_{M\theta t}, \nu_{N\theta t}, E_{45t})$

$(E_{Mc}, E_{Nc}, E_{\theta c}, \nu_{MNc}, \nu_{M\theta t}, \nu_{N\theta c}, E_{45c})$

$(\alpha_M, \alpha_N, \alpha_\theta, \sigma_M, \sigma_N, \sigma_\theta)$

15. enter (IPRESS) data sets

(I, J, PRESS)

16. enter (ISHEAR) data sets

(I, J, SHEAR)

17. Answer to query "Do you want summary of input data?"

8. References

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